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A TREATISE
ON
REGIONAL SURGERY
VOLUME II

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VOLUME II

THE ABDOMEN—THE GENITO-URINARY SYSTEM—THE SPINE. . . . . .

VOLUME III

THE UPPER EXTREMITY—THE LOWER EXTREMITY . . . . . .

A TREATISE
ON
REGIONAL SURGERY

BY VARIOUS AUTHORS

EDITED BY
JOHN FAIRBAIRN BINNIE, A. M., C. M., F. A. C. S.
KANSAS CITY, MISSOURI.

VOLUME II

WITH 213 ILLUSTRATIONS

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REGIONAL SURGERY

THE ABDOMEN

SECTION I

ABDOMINAL WALL

By
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Kansas City, Missouri

Innervation.—The anterolateral abdominal wall is supplied by the lower seven thoracic nerves and the iliohypogastric and ilioinguinal branches of the first lumbar nerves.

The sixth and seventh nerves supply the skin over the "pit of the stomach," the eighth nerve corresponds to the middle linea transversa, the tenth to the umbilicus, the distribution of the twelfth (or subcostal) extends to within 5 cm. (2 in.), of the symphysis, that of the iliohypogastric is below this.

According to Brewer, "the course of the twelfth thoracic nerve is indicated by a line from a point 12 mm. (½ in.) below the tip of the twelfth rib to the spine of the pubis on the opposite side; that of the eleventh thoracic nerve by a line from a point 12 mm. (½ in.) below the tip of the eleventh rib to the middle of Poupart's ligament on the opposite side; that of the tenth thoracic nerve from a point 12 mm. (½ in.) above the tip of the eleventh rib to the anterior-superior iliac spine of the opposite side. The line indicating the course of the ninth nerve is from a point just below the osteochondral junction of the ninth rib horizontally inward; that of the eighth thoracic nerve is from a point just below the outer end of the eighth cartilage horizontally inward to a point 12 mm. (½ in.) to the median side of the chondral border and then upward and inward parallel with the border and 12 mm. (½ in.) internal to it. In great abdominal distention or obesity these lines would not hold."

Nerve branches connect the lower dorsal nerves (D. 5 or 6 to 9 or 10) with the corresponding sympathetic ganglia and from these in turn arise the splanchnic nerves going to the solar plexus. In this way the

nerve supply of the abdominal wall is most intimately related to that of the abdominal and some of the thoracic viscera. The receptors for stimuli coming from the viscera do not seem capable of translating these stimuli into terms of pain and hence when there is no excess of stimuli we are not conscious of their presence. If, however, *e.g.*, in ulcer of the stomach or appendicitis, too many stimuli are sent up the sympathetic

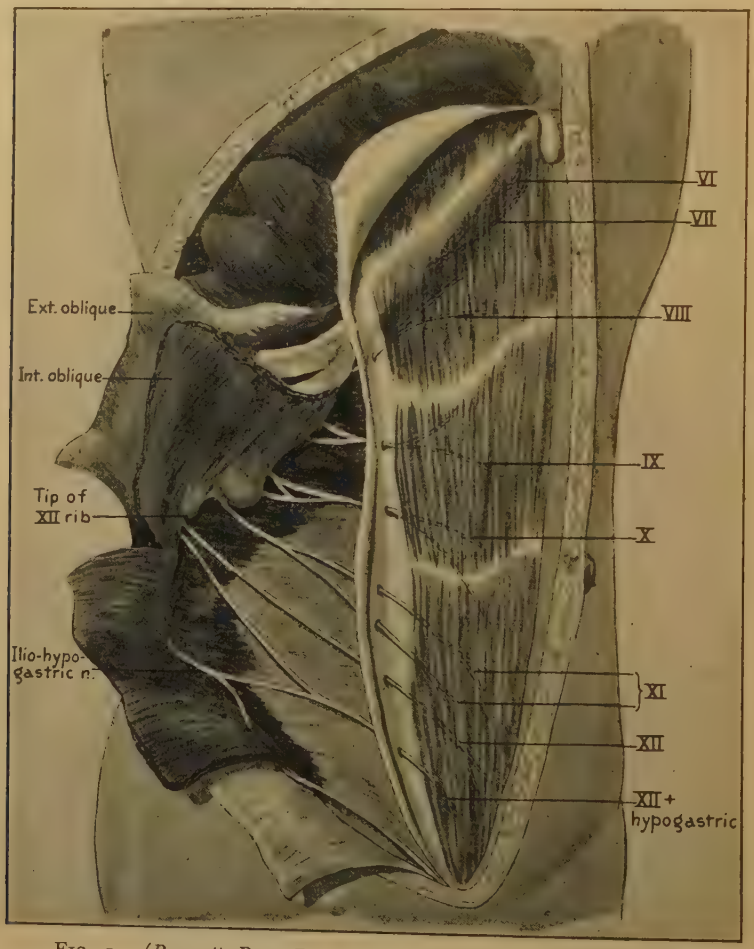

FIG. 1.—(*Pannett, Proc. Roy. Soc. Med. London, VII, Surg. Sect.*)

nerves, they radiate from their own receptors and influence receptors belonging to the cerebro-spinal system of nerves where they are translated into terms of pain.

As the receptors for the nerve supply of the abdominal wall are closely related to the receptors of the splanchnic nerves, it is evident

that when the latter are over-stimulated there must be a radiation of stimuli to the former. Thus in intra-abdominal lesions, such as appendicitis, there are pain and tenderness in the abdominal wall not necessarily directly over the appendix itself but in that area supplied by spinal nerves most closely related in origin with the sympathetic nerves of the appendix (Fig. 1). Furthermore there is rigidity of the muscles supplied by the irritated nerves. In similar fashion is explained the pain in the back so commonly noticed in gall-stones, gastric ulcer, etc., etc., as well as the shoulder pain of gall-stone disease.

The lower thoracic nerves supply not only the abdomen but also the intercostal muscles and the costal pleura. Nerve impulses passing up these nerves, say from a low pleurisy or pneumonia, are often referred to the abdominal distribution of the nerves, and mistakes in diagnosis have thus resulted. Mackenzie (Symptoms and Their Interpretation) has pointed out that stimulation of any individual bundle of nerve fibers, as it leaves the cord to go to one of the flat abdominal muscles, causes contraction of the muscle fibers supplied by it and not of the whole muscle and that the contraction of a larger or smaller portion of the muscle in response to a visceral stimulus may remain for an indefinite period, causing a tumor-like swelling. In cases of appendicitis where the examiner believes that he can palpate the enlarged vermiform appendix, it is usually such contracted muscular fibers which he feels and as there is also hyperalgesia of the muscle the patient complains of pain and thus tenderness of the vermiform appendix is erroneously believed to be present. Undoubtedly many of the so-called phantom tumors of the abdomen are of similar origin.

Wounds of the Abdominal Wall.—Any wound of the abdominal wall, unless unmistakably superficial, ought to be explored, *not* with a probe, but by careful aseptic enlargement. Formerly most surgeons agreed that this remark did not apply to bullet wounds received in war on the theory that wounds inflicted by the modern high-power rifles, when not immediately fatal, have a much better prognosis without operation than when operation is performed even by skilled surgeons with proper hospital facilities. In civil practice the reverse is true. Beavis and Souttar (Brit. Med. Journ., Jan. 9, 1915) from their large experience in Belgium find that the most recent bullets "are so balanced that on impinging on soft tissues they turn over and pass through backward, mushrooming as they go." The result is that intestinal wounds are so large and lacerated that without operation recovery could hardly be expected. These operators had excellent success in

patients operated on in from six to eight hours after receiving their wounds while they never saw recovery ensue without operation where there was undoubted intestinal injury. The general experience of surgeons in the Great War supports these views. When operating on any wound which may possibly penetrate the peritoneal cavity the surgeon must of course be prepared to treat lesions of any viscus *secundum artem.* If the wound has with certainty penetrated the peritoneum it is often advisable to open the abdomen at some other place, preferably the middle line so as to avoid working through already contaminated tissues and to gain easy access to all the viscera. When the operation is completed, the original wound must be cleansed, preferably excised, and either closed or drained according to circumstances.

Bruises and *contusions* of the parietes are of importance principally from the danger of the rupture or tearing of internal organs. Sudden muscular strain may, in the debilitated, cause partial or complete rupture of the rectus, most commonly below the umbilicus. The other abdominal muscles are rarely involved. The symptoms are sudden, sharp pain, effusion of blood, and, if the patient is not too fat, a diastasis may be palpated. Healing usually takes place satisfactorily if the parts are kept at rest with the patient in a comfortable position. Strapping of the abdomen with adhesive plaster is often grateful. If the debilitating predisposing cause of the rupture is some infective disease such as typhoid, the injured muscle and effused blood are apt to become infected and form an abscess. Colon bacilli are often the infective agent. Hernia may develop as a result of the local weakening of the parietes.

As in other situations, blows inflicted upon the muscles when they are in a state of contraction are well calculated to produce rupture of their fibers.

A heavy blow from a fist or blunt weapon upon the abdomen may cause the recipient to "double up," become pale, break into a cold sweat, struggle for breath and show signs of great distress. Vomiting is common. Usually recovery is prompt. In the athletic field a man who has suffered this accident is said to have had "his wind knocked out." The cause of the symptoms is generally believed to be trauma of the solar plexus producing among other things a temporary paralysis of the diaphragm. If the muscles of the abdominal wall are well developed and are warned of an approaching blow they are commonly capable of protecting the abdomen; thus in the prize ring a single blow on the epigastrium rarely ends the fight. A blow in the hypogastrium

or "below the belt" is specially dangerous not so much because of nerve shock as because the muscular protection is less efficient than higher up and because of the dangers of rupture of the urinary bladder and possibly of the cœcum.

The abdominal wall may be even severely injured by blows and contusions without there being any grave injury to the contained viscera and under these circumstances recovery usually ensues without complications. Grave injuries to the viscera are common after all grades of contusions. There may be rupture of hollow viscera; rupture of solid viscera such as the liver; tears of the omenta or mesenteries with consequent hemorrhage and the possibilities of internal hernia. A comparatively slight blow on an abdomen unprotected by strong contracted muscles may easily cause rupture of an intestine which happens to be tensely distended with gas or of a bladder full of urine. When a heavy wheel runs over the abdomen while the spine is supported by the ground, grave internal injury is almost sure to be inflicted.

Symptoms.—The general symptoms of abdominal injury whether of the abdominal wall or of the contents are notably those of shock, along with pain, tenderness and rigidity of the abdominal muscles. If the parietes alone are affected, the shock passes off early, rarely lingering as long as twenty-four hours; the pain, tenderness and rigidity soon become localized at the site of injury and lessen in intensity. Hemorrhage may manifest itself by restlessness, air-hunger, the large-waved hemorrhagic pulse and by progressive lowering of the hemoglobin content of the blood. Dulness in the flanks and resonance over the liver are of little value in the diagnosis of hemorrhage or of visceral rupture.

The signs of injury to internal organs may be unmistakable, *e. g.*, vomiting of blood, passage of bloody urine, etc., but in the absence of such signs it is often impossible to exclude the presence of lethal lesions. If one waits until there are clear evidences of intestinal rupture or of bleeding, one has waited until treatment will probably be without value.

Each case must be judged for itself. In general terms it may be said that if the symptoms are not mitigated in a few hours it is wise to open the abdomen when, if nothing is found, the harm done is infinitesimal compared with the good to be expected from prompt stoppage of bleeding or from the proper treatment of ruptured organs.

The abdominal wall is subject to most of the inflammations and neoplasms so common in other localities.

Herpes Zoster.—Affections of the posterior nerve roots (hemorrhage, inflammation) give rise to herpes zoster. The pain, elevation of tem-

perature, feeling of malaise, etc., when the abdominal wall is the area of distribution of the affected nerves, may well give rise to error in diagnosis before the appearance of the eruption. James Mackenzie (Symptoms and Their Interpretation, p. 57) writes, "In places where no eruption appears, or long after the eruption has healed, pains of a most excruciating character may be experienced. In their description of these pains the patients will state that they feel deep in the belly, and not infrequently the patient attributes these to his bowels and consults his doctor lest a cancer or some other painful disease has affected his bowels. These pains of herpes zoster are also often somewhat vague and difficult to localize with precision, though they are always felt within an area of definite limits."

Neoplasms.—Most of the neoplasms occurring in the abdominal wall present the same characteristics and demand the same treatment as when they appear in other localities. A few of them, however, in this region have peculiarities which call for special consideration. It is very common to find *lipomata* in the middle line especially above the umbilicus and lying between the peritoneum and the aponeurosis. Such tumors come to protrude through openings in the aponeurosis and may show impulse on coughing. They frequently cause digestive disturbances. In their growth they often draw with them a pouch of peritoneum through the aponeurosis and thus constitute a hernia. The treatment of these tumors is identical with that of hernia.

Great masses of fat may be more or less uniformly distributed subcutaneously over the abdomen, giving rise to an ugly and inconvenient pendulous deformity. To women especially, this aggregation of fat is very annoying and its excision through a long curved hypogastric incision like Pfannenstiel's, is much appreciated.

Desmoids.—Fibroid tumors occurring in the abdominal wall are known as desmoids. Hertzler (Treatise on Tumors, p. 439) writes, "These are quite definite in both pathology and incidence; they stand midway between sarcomas and fibromas, and occur most frequently by far in women between twenty and thirty-five years who have borne children. They have been observed in the imparous and in men. In a considerable precentage of cases they are first observed during pregnancy, and when they exist before pregnancy often take on rapid growth during that period. The reason for this association is not understood. They occur most frequently on the posterior layer of the rectus sheath above the umbilicus (Olshausen) or in the flank below the umbilicus (Pfeiffer). They are sometimes observed in the lateral abdominal walls

intimately attached to the costal cartilages or the crest of the ilium. Rupture of the rectus during labor has been suggested as causative, a suggestion strengthened by the fact that ruptures of the rectus usually take place in the posterior surface of the muscle. Against this is advanced the argument that the tumors do not go out from the muscle, but from the fascia. Desmoids which are attached to the bone and cartilage likewise apparently go out from the fascia."

The tumors vary from being merely palpable to the size of a child's head. They may be disc-shaped or oval, very hard or somewhat soft and on section they are white or pinkish white and sometimes fibrous bands can be made out. Calcareous infiltration and, in the large ones, myxoid degeneration have been noted. The history is that of cellular fibroma often resembling in appearance a sarcoma, even to the extent of showing some infiltration of surrounding structures. In spite of their rather menacing microscopic characteristics desmoids show little tendency to recur after excision. Usually the tumors increase in size slowly and cause inconvenience from their bulk rather than from pain, but to this there are exceptions. On palpation the tumor is felt as an oval flattish mass usually along the course of the rectus muscle. When the rectus is lax, the growth is mobile but when the muscle is voluntarily contracted it becomes fixed. Desmoids situated elsewhere than in the territory of the rectus are often very difficult of diagnosis especially in the obese, being mistaken for various intra-abdominal growths.

The only treatment worthy of consideration is excision. When the tumors are large it may be very difficult to effect closure and to reconstruct an efficient abdominal wall. Under such circumstances autoplasty with free flaps of fascia is of great value.[1]

Varicose veins of the abdominal parietes are very common. This condition (caput medusæ) is often nature's method of avoiding obstructions situated in the portal vein or in the inferior vena cava. When

[1] C. Pfeiffer (Beitrage z. klin Chir., XLIV, 334) from analysis of 400 cases collected from various sources comes to the following conclusions. Eight cases were children. Heredity seems to play no rôle. The lower abdomen especially on the right side is the favorite site. The point of origin was the rectus in 43 per cent.; the rectus and its sheath in 17.5 per cent.; the other abdominal muscles in 17 per cent.; the superficial fascia 3.7 per cent.; the deep fascia 13 per cent. In the rest of the cases (5.8 per cent.), several muscles being involved, the origin was obscure. The tumors were usually more or less cellular fibromata, more rarely pure sarcomata. Occasionally myxomatous tissue was present. Fibromyomata were rare and seen only in women. Women were the subjects of the desmoids in 89.4 per cent. of the cases and 94 per cent. of these women had born children. Pathological distention of the abdomen does not predispose to desmoids. Pfeiffer believes that hypertrophy of the abdominal muscles and fibrous tissues during pregnancy is a predisposing cause. The primary mortality after operation was 3.5 per cent. when the abdomen was opened and 1.05 per cent. when it was not opened. A cure was obtained in 50 per cent. of the males and 90 per cent. of the females.

there is portal obstruction, blood is dammed back, distends the vein of the round ligament of the liver (parumbilical vein), finds its way into the superior and the deep epigastric veins and so on toward the heart. When there is obstruction to the inferior vena cava or to the iliac veins, the blood is dammed back into the deep epigastrics which it dilates until the valves are rendered incompetent and so reversing the circulation finds its way toward the heart by the superior epigastric and parumbilical vessels.

The Talma-Morrison operation for ascites endeavors to supplement the above natural avenues of collateral circulation.

Affections of the Umbilicus and Urachus.—It has been shown in the chapter on development, Vol. I, p. 74, that the urachus which normally extends as a cord from the urinary bladder to the umbilicus may remain patent either wholly or in part. The urachus as a rule lies between the parietal peritoneum and the parietes but occasionally it is provided with a meson and thus may be intraperitoneal. When the bladder end of the urachus remains patent, a blind internal fistula or bladder diverticulum results. Similarly when the umbilical end is patent there is a blind external fistula. Complete fistulæ result from complete non-closure of the urachus. Frequently both ends of the urachus become obliterated but one or more segments remaining patent may give rise to cysts. Uncomplicated cysts of the urachus usually contain clear fluid and may vary in size from being merely perceptible to huge dimensions. When a cyst develops in a urachus which happens to be provided with a meson it will almost inevitably be mistaken for some other form of intra-abdominal tumor.

Alban Doran has reported (Trans. Roy. Soc. Med., 1909) a cyst of the urachus to the right of the middle line. The classical site for urachal lesions is of course the middle line.

Patent portions of the urachus are very subject to infections and any phlegmon of the abdominal wall in the middle line below the umbilicus ought to make the surgeon think of this possibility. Malignant neoplasms of the urachus are rare.

Symptoms of Patent Urachus.—Very frequently the condition is discovered accidentally or at autopsy, no symptoms having developed. Blind internal fistulæ may give rise to persistent and obscure cystitis the cause of which is discovered only by cystoscopy. Blind external fistula may be recognized by a slight mucous discharge producing a moistness about the umbilicus, sometimes by the existence of a bud of granulation tissue there. Usually symptoms of infection draw atten-

tion to the trouble and often a firm cord can be palpated, extending downward from the navel toward the bladder and through this cord it may be possible to pass a fine probe. When the fistula is complete the discharge may have a urinous odor or pure urine may escape. Urinary calculi have been removed from fistulæ.

Treatment.—In the presence of acute inflammation, the treatment consists in incision and drainage; under other circumstances excision may be practised provided that the symptoms or the extent of the trouble are sufficient to justify operation.

During early development a communication exists between the intestine and the yolk sac; Meckel's diverticulum is a frequent reminder of this stage of development. If this communication persists, a fistula may be left, leading from the umbilicus to the ileum and through this fæces may escape. The small intestine may become prolapsed through the fistula and cause obstruction. Partial persistence of the fœtal structures may occasion cysts and fistulæ of the abdominal wall and umbilicus. The cysts and fistulæ are lined with intestinal mucous membrane and contain mucus.

The so-called adenomata of the umbilicus consist of eversions of umbilical fistulæ and appear as red, velvety nodules the size of a pea or cherry, secreting mucus and provided with a pedicle. They are easily removed (Cullen, Journ. A.M.A., Feb. 11, 1911).

Neoplasms of the Umbilicus.—Primary carcinomata, adenocarcinomata and sarcomata are rare.

Quenu et Longuet (Rev. de Chir., XVI, 97) have shown that carcinomata of the liver and stomach may readily extend to the umbilicus through the lymphatics of the round ligament.

Abdominal Incisions.—A good incision through the abdominal wall must (*a*) give proper access to the disease to be investigated and treated and ought to be capable of any necessary enlargement; (*b*) be capable of the easiest and most efficient closure with the least possible danger of subsequent hernia or paralysis.

The classical incision is that in the *linea alba* and has the advantages of giving good access, of being easily enlarged and of dividing no important nerves or vessels.

In closing the wound, however, only comparatively thin layers of aponeurosis are coapted and hernia is a frequent sequel. To avoid this defect in closure the incision is commonly made slightly to one side of the linea alba, the sheath of the rectus is opened longitudinally, that muscle is either retracted outward or its fibers split and the tissues

behind are cut. This incision gives as good access as that through the linea alba, permits of suturing in several layers, giving broad surfaces for union and, if not far removed from the middle line, avoids any serious nerve section. It must be noted that all vertical incisions above the umbilicus are difficult to close on account of tension. Sutures of the peritoneum and posterior rectus sheath are particularly prone to tear through the tissues. On many occasions when the writer has with much difficulty inserted these sutures in the epigastrium he has felt sure that they have given way after the rest of the wound has been closed. Vertical incisions through the rectus or at its outer margin inevitably destroy its nerve supply to a greater or less extent and theoretically at least, ought to produce a crippling paralysis of that muscle. Practically, one finds comparatively few cases of serious paralytic lesions following the long vertical wounds so commonly used in the surgery of the gall-bladder and appendix. When, however, such muscular paralyses do occur and make themselves prominent as a sort of hernia the surgeon wishes he had spared the nerves.

For particular pieces of intra-abdominal work various incisions have been devised by which the different layers of flat muscles and aponeuroses are split in the direction of their fibers, the deeper layers being exposed by splitting and retracting the edges of the more superficial. Such are the "Grid-iron" or "Criss-cross" incisions, the best known example of which is that of McArthur and McBurney used in appendectomy.

McArthur-McBurney Incision.—A 3-in. incision is made beginning 1 in. above a line joining the anterior-superior spine and the umbilicus of the ilium and crossing it at a point about 1½ in. from the anterior-superior spine. The cut penetrates the subcutaneous tissues and is parallel to the fibers of the external oblique. The fibers of the external oblique are now separated throughout the whole length of the wound and well retracted so as to expose the internal oblique with its fibers running approximately at right angles to the wound. Splitting and retraction of the internal oblique exposes the transversalis muscle which is also penetrated and retracted in the same manner. The transversalis fascia and peritoneum are now incised. In closing, the peritoneum and transversalis fascia are sutured with a continuous stitch. As the various muscle and aponeurotic planes have been split in the direction of their fibers their wounds tend to close as soon as the retractors are removed. A few stitches in each tissue plane in-

sures a proper reconstruction of the essential belly wall. The skin wound may be closed in the fashion which best pleases the surgeon.

When one considers that the aponeuroses of the abdominal wall are the tendons of the flat muscles (oblique and transverse) and that these are inserted into their fellows of the opposite side, one must realize that a so-called longitudinal incision is *physiologically* transverse in that it must cut the above tendons more or less transversely. This remark does not, of course, apply to incisions of the rectus but transverse division of the recti especially above the umbilicus does not seem to weaken the muscle greatly, it rather merely makes a new *inscriptio tendineæ.*

The so-called transverse incisions of the abdominal wall are usually more or less oblique or curved so as to run parallel to the course of the nerves. A short vertical cut in the middle line is often a useful addition to the transverse and does not materially add to the difficulty in closure.

In the lower abdomen Pfannenstiel's incision is based on correct anatomical principles and gives good access to the pelvic organs. The skin and aponeurosis are divided transversely (a curved transverse incision with convexity downward is a good modification); the aponeurosis is dissected from the recti and retracted upward and downward; the recti are separated from each other and the peritoneum is opened by a vertical incision. Closure is easy and the result is a very secure abdominal wall with a practically invisible scar. The principal disadvantage of Pfannenstiel's incision is that where drainage is demanded in infected cases, the wide opening of tissue planes may favor the spread of infection in the parietes.

A favorite means of gaining entrance into the abdomen is through a vertical incision a little internal to the outer margin of the rectus muscle. (Lennander, Battle, Kammerer, Jalaguier etc., etc.) After the anterior layer of the rectus sheath has been divided the muscle is retracted inward and the posterior layer of the sheath with the peritoneum is divided along a line corresponding to the skin incision. When the peritoneum has been sutured, the muscle is allowed to fall back into place and the anterior layer of the sheath and later the skin are stitched. Very firm closure is effected but the nerve supply of the rectus is liable to be destroyed. An identical incision may be used near the inner border of the rectus, the muscle being retracted outward. In this the nerves are not jeopardized.

(Much information regarding abdominal incisions is contained in the following articles:

Rockey, N. Y. Med. Record, Nov. 11, 1905; Maylard, Brit. Med. Journ., Vol. II, 1907; Assmy, Beitrage z. klin. Chir., XXIII; E. Boeckmann, St. Paul Med. Journ., June, 1910; Sprengel, Archiv für klin. Chir., XCII, 536; Fritz König, Zent. für Chir., 20 Ap., 1912; R. E. Farr, Journal Lancet, Nov. 1, 1912; Pannett, Proc. Roy. Soc. Med. VII, 1913–14.)

When so much of the abdominal wall has been destroyed, *e.g.*, in the removal of parietal neoplasms, that the ordinary means of closure are insufficient, the resources of plastic surgery must be utilized. Mayo has shown that even large abdominal openings, such as in umbilical herniæ, may be closed by making their upper and lower edges overlap. If such means fail, then some form of implantation or transplantation becomes necessary.

A. M. Phelps replaced areas of lost aponeurosis by means of an entanglement of wire stitches; Willy Meyer and Willard Bartlett attained the same end by implanting already prepared mesh works of silver wire, while McCosh used perforated celluloid plates. These foreign materials are well borne by the tissues and form the nucleus of a strong mass of connective tissue.

Instead of using foreign material, sheets of fascia may be dissected from the thigh, chest or back of the patient and sutured as a patch to the freshened edges of the defect. Such free or non-pedunculated transplants are of great value. Transplants from animals of another species are almost invariably failures while those from other individuals of the same species usually fail. Autoplasty is the method of choice.

Pedunculated flaps from the aponeurosis near the defect may be used but it is very doubtful if the pedicles, laboriously provided are of any great value.

SECTION II

HERNIA

By

J. F. BINNIE, A.M., C.M., F.A.C.S.

Kansas City, Missouri

The abdominal wall consists of three primary layers, viz., (*a*) the peritoneum, (*b*) the skin and (*c*) between them that layer of muscles and fasciæ or aponeuroses which constitutes what may be named the essential belly wall. At an early period of development the parietal peritoneum is formed from the somatic mesoderm, and the skin from the epiblast (Fig. 2). At a later date the ventral myotomes push forward

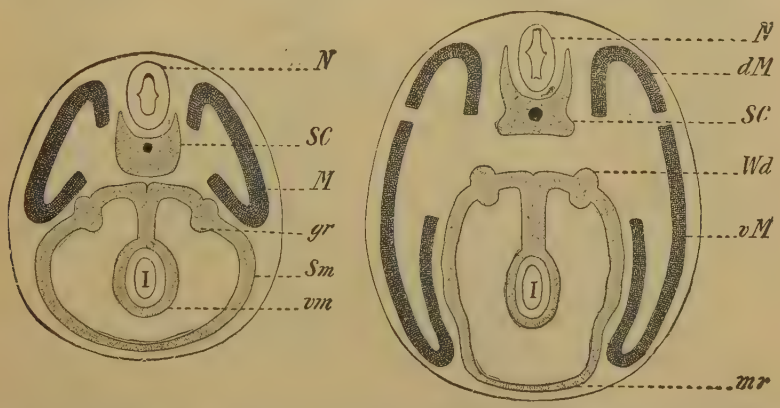

Fig. 2.—Diagrams illustrating the history of the gastral mesoderm. (*McMurrich.*) *dM*, Dorsal portion of myotome; *gr*, genital ridge; *I*, intestine; *M*, myotome, *mr*, membrana reuniens; *N*, nervous system; *SC*, sclerotome; *Sm*, somatic mesoderm; *vm*, splanchnic mesoderm; *vM*, ventral portion of myotome; *Wd*, Wolffian duct.

between the somatic mesoderm and the epiblast to become fused in the middle line. This fusion is very often imperfect and thus openings frequently exist through the essential belly wall especially in the median line.

Other points of weakness in the essential belly wall necessarily exist where it is penetrated by structures like the spermatic cord, the round ligament, various blood-vessels such as the femoral, etc. (Fig. 3). Besides the numerous weak points incident to development, similar weak-

nesses may be produced later in life by various causes, such as separation of the recti muscles by pregnancy or ascites, destruction of limited portions of the essential belly wall by infections, imperfect repair after operations, etc., etc.

When a weak spot exists in the essential belly wall, and when a pouch of peritoneum (hernial sac) protrudes into this weak spot, a potential hernia exists. The potential becomes an actual hernia as soon as any viscus makes its way into the sac.

Ordinarily a hernia consists of the following parts (Fig. 4):

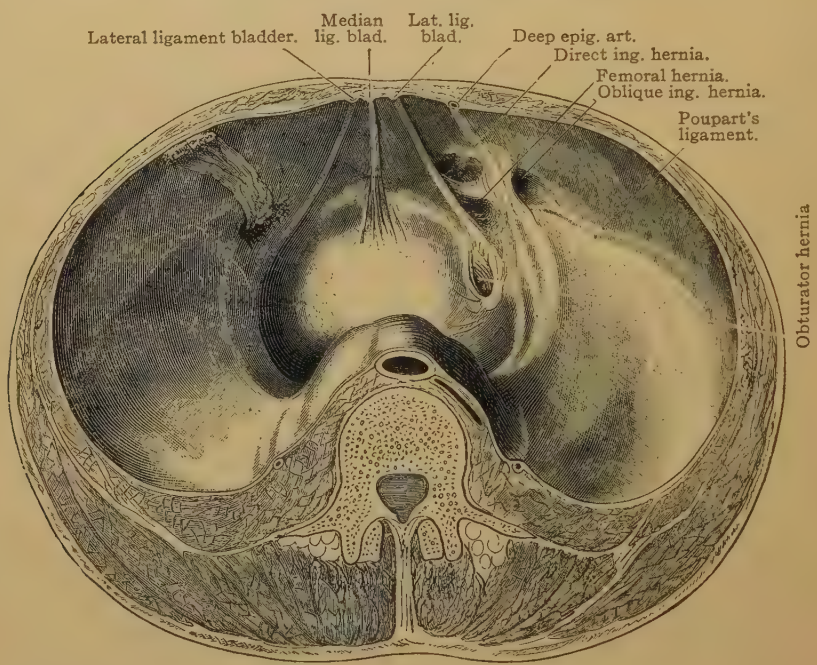

Fig. 3.—(*Hildebrand.*)

1. An opening or canal in the essential belly wall—the *hernial aperture.*

2. A peritoneal protrusion or pouch—the *hernial sac.*

3. One or more viscera or parts of viscera contained in the sac—*hernial contents.*

4. The skin and subcutaneous tissues covering the sac.

To the above there are some exceptions. If some abdominal viscera pass through an opening in the diaphragm two sacs may be present, one composed of peritoneum, the other of parietal pleura. If, after

operation, the peritoneum has not been properly united, viscera may pass through a hiatus in the essential belly wall to lie under the skin and no serous sac be present. This is a rarity.

Three principal theories have been propounded regarding the cause of hernia.

1. Mechanical theory. An increase in intra-abdominal pressure causes some of the abdominal contents to insinuate themselves through a weakened portion of the parietes pushing the peritoneum ahead of them in the form of a sac.

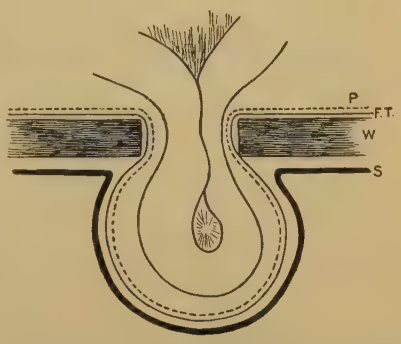

FIG. 4.—*s*, Skin; *W*, essential belly wall; *F.T.*, transversalis fascia; *P*, peritoneum.

2. Elongation or weakening of visceral supports permits the viscera to come into contact with weakened portions of the abdominal wall and there to be extruded by increased intra-abdominal pressure. The upholders of this theory deny the possibility of increased pressure producing a hernia if the visceral anchorage is normal.

3. Protrusion of the peritoneum as a sac is the primary and determining cause of hernia. The peritoneal protrusion may be congenital or acquired.

If a subperitoneal lipoma, by its growth or by accident, passes through an opening in the parietal musculature, it may drag after it an adherent portion of peritoneum and so produce a pouch (Fig. 5). This origin of the sac is rare. If, during the closure of a laparotomy wound, the peritoneum is everted and especially if the everted seam or ridge is caught between the sutured muscle and fascia, a pouching of the peritoneum is invited (Fig. 6). If the abdomen has been drained after operation, the edges of the peritoneal wound are apt to be pulled into the drainage canal and the pouch thus formed may be increased in depth by the natural contraction of the scar tissue dragging the peritoneum outward in the same way as it drags the epidermis inward, as evidenced by a depression in the scar (Fig. 7).

FIG. 5.—*S*, Skin; *W*, essential belly wall; *P*, peritoneum.

Undoubtedly most hernial sacs are congenital in origin. The researches of Bernstein, under Waldeyer's direction in the anatomical

institute of Berlin, are most instructive especially with regard to the great prevalence of potential herniæ. Out of 279 cadavera examined, in 72, whose average age was about 55 years, single or multiple herniæ or potential herniæ were present.

The following are some of the results of Bernstein's research (Archiv für Klin. Chir., C, p. 1094):

Number of subjects with hernia or potential hernia	72	= 25.8 per cent.
Males with hernia or potential hernia	51	= 18.3 per cent.
Females with hernia or potential hernia	21	= 7.4 per cent.
Males with single hernia or potential hernia	16	= 5.7 per cent.
Females with single hernia or potential hernia	2	= 0.7 per cent.
Males with multiple hernia or potential hernia	35	= 12.6 per cent.
Females with multiple hernia or potential hernia	19	= 6.7 per cent.
Total cases of single hernia	18	= 6.4 per cent.
Total cases of multiple hernia	54	= 19.4 per cent.

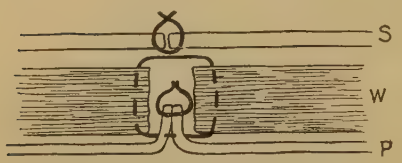

FIG. 6.—*S*, skin; *W*, essential belly wall; *P*, peritoneum.

FIG. 7.

It is very remarkable that while Bernstein finds the proportion between male and female cadavera the subjects of hernia (or potential hernia) is as 2¾ to 1, yet in the female the proportion of multiple to single herniæ is as 9½ to 1 and in males is as 2½ to 1.

The great frequency with which empty hernial sacs are found in the dissecting room gives strong support to the view that most hernial sacs are of congenital origin. The writer is, however, far from believing that *all* hernial sacs are congenital. Many, of course, are sequelæ of abdominal operations but apart from these obvious cases it is difficult to believe that repeated increases of intra-abdominal pressure cannot cause protrusion of loose peritoneum through weakened areas in the essential belly wall.

König writes: "There are two points requiring special attention. First, is it possible for intra-abdominal pressure such as is exerted by various expiratory movements to act more strongly at one place than at another? Admitting that this pressure acts, under similar circumstances, as if on the walls of a bladder filled with liquid, then a compression of the bladder such as would be exerted by the action of the

diaphragm would act with uniform power on all parts of the wall. It is, of course, not strictly correct to compare the abdominal contents to liquid. If every portion of the abdominal walls was of equal strength then it would be impossible to admit that there could be any gradual stretching or protrusion of an individual part of the wall under the increased hydrostatic pressure. But if the resisting power of the wall is not uniform then it will stretch where that resisting power is least, *i.e.*, where the wall is weakest. This condition of deficient strength is not uncommon at the various sites of herniæ. A number of things must occur before it is possible for the peritoneum to be pushed as a sac through a hernial opening by repeated applications of intra-abdominal pressure; otherwise one would expect herniæ to be a regular accompaniment of age."

"The abdominal wall and with it the peritoneum must have been subjected to a general or local stretching and relaxation. Such a condition of relaxation occurs, *e.g.*, after pregnancy which is so frequently followed by femoral hernia (Kingdon) or after exhausting diseases. The sudden, traumatic occurrence of a hernia is, in the light of the preceding remarks, unthinkable, but a portion of intestine may well be pushed into a preëxisting hernial sac by any force leading to a sudden contraction of the abdominal muscles." The fact that it is not very rare to have the neck of an old hernial sac dislocated downward so as to produce a bilocular sac supports the view that not all sacs are of congenital origin.

The "coverings" of a hernia vary with its site. In a diaphragmatic hernia the true sac, if there is one, protrudes into the thoracic cavity covered merely by the secondary sac of parietal pleura; in an inguinal hernia the sac is covered by the skin, the superficial fascia, the cremaster muscle and the transversalis fascia; in other herniæ the constituents of the coverings vary according to the anatomy of the part *but* in practice the various subcutaneous tissues are so stretched and fused together as to be indistinguishable from each other.

The Hernial Contents.—Any viscus or combination of viscera may be found in a hernia but omentum or intestine or both are the most common contents. Epiplocele and enterocele are the names given to herniæ containing omentum and intestine respectively. In an irreducible omental hernia the fat of the omentum frequently increases in amount until it forms a veritable lipoma and is so large that it loses all right or possibility of domicile in the abdominal cavity. On account of its long mesentery the small intestine is more often found in hernia

than the large. Of the large intestines the transverse colon, the sigmoid and the cæcum (with the vermiform appendix) are the parts most commonly herniated but it must be remembered that the ascending and descending colon are not infrequently provided with a mesentery and thus may sometimes enter the sac in the same way as the small intestine does and further that even when not provided with a mesentery, parts of the large intestine may "*slide*" through a hernial opening in a manner which will be described later.

The ovaries and the Fallopian tubes are sometimes found in herniæ. The urinary bladder is occasionally present. The stomach is sometimes found not only in epigastric and umbilical herniæ but even in inguinal and femoral. The liver and gall bladder may be found and, as a great rarity, a kidney may find its way into a hernia. In an enterocele only part of the circumference of the gut may be protruded as a diverticulum (hernia of the intestinal wall; Richter's hernia); this may be mistaken for a hernia of Meckel's diverticulum (Littre's hernia), which is itself an occasional occurrence.

Irreducible hernia is one in which it is impossible to return the contents into the abdomen by means of taxis (manipulation). The failure is generally due to adhesions between the contents and the sac. In most herniæ omentum is present and it may have so increased in size during its exile from the abdomen as to render its return through the hernial opening an impossibility.

Inflamed Hernia.—A herniated vermiform appendix is *at least* as liable to appendicitis as is one in its normal position. The same is true of other viscera. The commonest cause of inflammation in a hernia is trauma, often due to injudicious efforts at reduction. The usual phenomena of inflammation are present and result in roughening of the peritoneum and the deposit of exudates which temporarily glue together different peritoneal surfaces. The temporary adhesions may be absorbed or, as is more common, they are replaced by connective-tissue elements which grow into them and form permanent adhesions of the hernial contents to each other or to the sac. Adhesions may form such trabeculæ in the sac as to render the latter multilocular.

Incarcerated Hernia.—The herniated intestine has become obstructed; generally from distention by gas or from damming up in it of fæcal material. As fæces exist only in the large intestine, incarceration is most common in hernia of the large intestine—hence in umbilical hernia. There is no interference with the blood supply of the bowel.

Strangulated Hernia.—A strangulated hernia is one in which there is interference with the vascular supply of the hernial contents. When intestine is involved there is also interference with the passage of fæces, etc., partly on account of mechanical obstruction but also on account of the local lesions produced primarily by the altered vascularization. The hernial opening in the abdominal wall usually acts as the agent constricting the blood-vessels passing through it, but is by no means the only constrictor. Essentially the hernial sac is merely a protrusion of the parietal peritoneum which has passed out through a limited opening in the abdominal walls to expand again in the scrotum or subcutaneous tissues. The portion of the protruding peritoneum which occupies the hernial opening is necessarily thrown into folds and these folds in time become fused together so that a permanent fibrous ring is formed a little less in caliber than the hernial opening. This ring is the *neck* of the sac and may remain in its original site or may by sudden and repeated increases of abdominal pressure (coughing, heavy lifting or any severe straining) become dislocated outward and a new ring or neck be formed in the sac at the hernial opening. Thus a sac may have one or more constrictions and each or any of these may interfere with the blood supply of the contents. A hernia may exist for a long time without strangulation, but a sudden cough or strain may push so much omentum or intestine into the canal as to exercise pressure on the vessels or some injury may cause swelling of the hernial contents which thus become pressed against the unyielding hernial opening or sac neck with the same result. Distention of the bowel from any cause may cause strangulation as also may the gradual growth of the herniated omentum.

The blood supply of the hernial contents having been constricted the following phenomena manifest themselves: (1) Congestion from venous engorgement; the intestine and omentum become dark in color and their veins are distended. (2) Œdema promptly appears and fluid forms in the sac. The fluid may at first be clear but soon it becomes turbid and blood stained. The gut and omentum become dark in color and show scattered ecchymoses. (3) The peritoneum of the bowel loses its luster, becomes blackish or grayish and the gut walls, from œdema, are thickened and feel more or less like wash-leather. The turbid fluid in the sac may now have a feculent odor. (4) Gangrene makes its appearance. The gangrene may be diffuse or localized. Pressure at the neck of the hernia may be so great and localized as to cause perforation of the intestine at that place without necessarily producing the whole train of phenomena described above.

A small hernia is more subject to strangulation than is a large and old one where the hernial opening is roomy and the contents have become acclimatized to their extraabdominal habitation. A hernia rarely becomes strangulated on its first descent. Sir Thomas Bryant found "the average duration of an *inguinal* hernia previous to its becoming strangulated was 20, and of a *femoral*, 11 years." "The symptoms of strangulated hernia are those of obstruction. In old inguinal hernia of many years standing the symptoms are usually chronic; in recent hernia and more particularly of the femoral variety they are acute."

If a strangulated hernia is untreated, death results, unless sloughing through the skin takes place establishing drainage and a fæcal fistula.

Retrograde Strangulation.—(1) A *distal* portion of herniated omentum (Fig. 8) may find its way back into the abdomen the rest of ex-

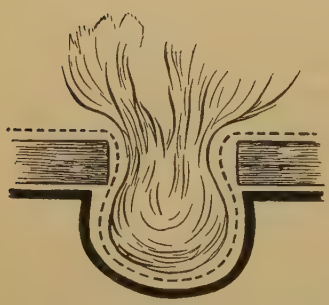

Fig. 8.—Retrograde omental hernia.

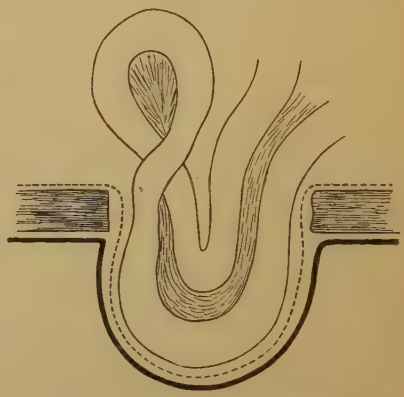

Fig. 9.—Retrograde hernia.

truded omentum remaining in the sac. If now the vessels of the returning prodigal become constricted, strangulation results, but inside the abdominal cavity instead of in the hernia. (2) Part of the loop of a herniated intestine (Fig. 9) may find its way back through the hernial opening alongside its afferent and efferent portions and become strangulated inside the abdominal cavity. (3) The herniated cæcum may have pulled the base of the vermiform appendix through the hernial opening with it but the tip of the appendix may remain in the abdomen. If now the vessels of the mesoappendix become constricted, retrograde strangulation results. In similar fashion the Fallopian tube has been strangulated.

Symptoms of Hernia.—The patients occasionally complain of obscure dyspeptic symptoms and of colicky pains; more frequently they merely experience a feeling of weakness at the site of the hernia but in the vast

majority of cases their attention is first attracted to the trouble by the presence of a swelling which may have appeared suddenly after a strain, such as of heavy lifting, accompanied by a sensation of something having "given way" or of pain or which may have been discovered accidentally and is accompanied by no symptoms whatsoever. Often the "swelling" is absent in the morning but present at night. The characteristic appearance of a hernia is of a rounded or pyriform swelling which increases in size on coughing or straining (impulse on coughing); on percussion there may be a tympanitic note, if intestine is present, or a dull note, if omentum; on palpation, elasticity is characteristic of intestine; a soft doughiness with slight or absent impulse on coughing is more characteristic of omentum. On manipulation (taxis), if the hernia is reducible, the intestine may give a sensation of gurgling as it slips back, omentum gives of course no gurgling. The patient ought to be examined both when lying down and standing as in the latter position the hernia is most prominent and in the former it is more easily reduced. All manipulations must be made with great gentleness and if the hernia is large and of old standing the patient knows far better how to reduce it by taxis than can the surgeon.

Symptoms of Strangulated Hernia.—The general symptoms of strangulated hernia are those of intestinal obstruction from any cause.

In *acute* cases there is severe abdominal pain in the umbilical region with more or less collapse or shock. Vomiting occurs, first of the stomach contents, then of bitter greenish yellow fluid (biliary vomit), later of large quantities of dirty brown foul fluid with a fæculent "stink" (stercoraceous vomit).

After the large intestine has emptied itself, constipation becomes absolute, neither fæces nor flatus passing. There are some exceptions to this rule, *e.g.*, when only a small portion of the circumference of the gut is involved, as in Richter's hernia, and in some cases of strangulated omental hernia. It must be remembered that the obstruction may be due not merely to mechanical causes but to peritonitis, whether in the hernia itself or in the abdominal cavity.

The tongue is at first covered with a dirty fur; later it becomes dry and red. The pulse becomes progressively more rapid and weak while the temperature may become subnormal. The skin becomes cold and clammy and the features are pinched.

The local signs of hernia are present, the tumor being tense, painful, tender and *without* impulse on coughing.

In old hernia the symptoms may be more chronic. Before vomiting

begins the patient will probably have "complained of some general abdominal uneasiness, such as flatulence, a feeling of faintness, nausea, and fulness, with local pain in the hernia; the nausea, however, will soon be followed by persistent eructations, hiccough and vomiting; in most of the cases constipation too will be present, though in some the desire to go to stool will be great and the straining severe. The local signs of strangulation or obstruction are often so slight as to be disregarded by the patient, and unless the hernia is discovered by the surgeon, his attention will probably not be drawn to it by the sufferer. Thus at Christmas, 1870, I reduced a femoral hernia by the taxis, strangulated for a hundred hours in a man who was unconscious of its presence till a few hours before." (Bryant, Practice of Surgery, I, 653.)

Other general symptoms common to strangulated hernia, obstruction and peritonitis are abdominal rigidity and distention. Unless the strangulation is relieved, the symptoms progress; vomiting may be replaced by simple regurgitation of foul fluid from the mouth; there is great weakness; the breath is horribly fœtid and sordes appear about the mouth and lips. The immediate cause of death is usually exhaustion, general peritonitis or pneumonia. The symptoms of strangulation being such as they are the surgeon must look for hernia in every case of suspected obstruction of the bowels. When symptoms of strangulation exist in such obscure herniæ as the sciatic variety the causal condition is usually discovered during operation undertaken for obstruction or what Battle calls the "acute abdomen."[1]

Principles of Treatment.—*Palliative Treatment.*—Reduce the hernia and keep it reduced by means of a suitable truss. The classical method of reduction is by manipulation or taxis. If gentle taxis is not promptly successful it should not be continued. In days of yore the patients were rendered relaxed by hot baths, opium, enemata of tobacco, etc.; these means were all superseded by the use of an anæsthetic. Today operative treatment is so safe and successful that if an anæsthetic is required before reduction is safely possible, it is far better to proceed to operation unless the general condition of the patient prohibits. It is entirely improper to use taxis on any case of strangulated or inflamed hernia; open operation is so much safer.

Example.—Inguinal hernia.

Taxis.—Place the patient on his back, the shoulders raised and

[1] In connection with strangulated hernia the student is urged to study Mr. Paul's chapter on Intestinal Obstruction.

the legs partially flexed and rotated inward. Gently but steadily grasp the neck of the sac to fix it and to guide the contents into the abdomen as they are being reduced. With the other hand raise the tumor if large, and *gently* compress it so as to empty it of its "serous, gaseous, fæcal or venous contents and thus lessen its size." Pull the tumor gently from one side to the other so as to loosen the constriction at its neck. Sometimes by pulling the hernia outward and gently kneading its neck one may so straighten the contents in the hernial aperture that reduction becomes possible. Direct pressure on the hernial tumor itself is a poor method of attempting reduction. If the hernia has existed for a long time and has been reducible, the patient himself is far more likely to be able to effect reduction safely than is the surgeon.

Do *not* persist in trying taxis if it is not promptly successful, if it causes pain, if the hernia is tense and if symptoms of inflammation or of strangulation are present.

A good indictment of taxis when applied to strangulated hernia is to be found in the causes of the persistence of the symptoms, pain, vomiting, constipation after apparently successful taxis.

Rose and Carless give these causes, as follows:

"(1) Infective gangrene may involve the released coil of gut and spread to the portion above it, causing death from peritonitis and toxæmia. (2) Ulceration and perforation may occur along the 'constricted groove.' (3) The rupture reduced may not be the one which has given rise to the symptoms, an internal hernia, or one in some other region, coexisting. (4) The strangulation may have been caused, not by the neck of the sac, but by a slit in the omentum contained in the sac. Reduction in such a case would not relieve the symptoms, the whole mass being returned into the abdomen. (5) A volvulus may have been present, either wholly or partly in the sac, and may have been reduced untwisted. Occasionally a volvulus is produced by the manipulations of reduction, especially when the mesentery has been lengthened in long-standing hernia and the bowel paralyzed by the strangulation. (6) The hernia sac may have a diverticulum or pocket communicating with it at its upper end (intraparietal interstitial hernia), or it may be shaped like an hourglass. It is possible to reduce the intestine from the lower portion of this so-called hernia *en bissac* into the upper pocket, and then of course the symptoms persist. (7) Reduction *en bloc* or *en masse* ought never to be seen, as it can only occur when a considerable, and therefore an unjustifiable amount of force

has been employed. The sac and its contents are together reduced from their superficial position to the deep aspect of the abdominal parietes, the hernia then lying between the muscular planes or in the subserous areolar tissue, and the constriction remaining. The hernia gradually disappears, but without the characteristic gurgle. In such a case the sac sometimes gives way, the intestine and the portion of the neck which compresses it being pushed upward. When occurring in the inguinal region it is recognized by the persistence of the symptoms, and by the fact that a finger inserted into the canal, which is unduly patent, detects a tense rounded swelling at its upper end. It also happens, but less commonly, in the femoral region, and in either variety the hernia may slip down again a short time after its apparent reduction."

Truss.—Most trusses consist of a steel spring which partly encircles the body and holds a suitable pad over the hernial aperture. The pad must never press against a bone. The strength of the spring should be such as suffices to retain the hernia in place during any exertion the patient may be expected to make. It would be absurd to provide a man of sedentary habits with a truss strong enough for a stevedore. A well fitting truss should remain in position and *be comfortable* no matter what the posture assumed by the wearer. It should be put on before the patient rises from bed and be taken off only after returning to bed. A special truss ought to be worn during the bath. These precepts are theoretically correct but no one ever carried them out fully. Most patients quickly learn how to manage their trusses. One useful hint is that the truss is most comfortable when worn *outside* fine underwear. The simpler the truss the better. For inguinal hernia the writer has found the French truss *without* a perineal band suitable in most cases.

Indications for Operation.—Operation is imperative in strangulated, incarcerated and inflamed herniæ.

Operation is generally imperative in irreducible herniæ.

Operation is imperative when the hernia cannot be kept reduced by a properly chosen truss.

Operation is imperative when the patient desires to enter the army or navy or if he proposes to travel or live out of easy reach of good surgical aid.

Operation is proper in almost any hernia provided the patient's health is not such as to prohibit even such an innocent surgical intervention.

Principles of Operation for Hernia.—1. Expose the sac and the hernial aperture by a suitable and free incision. After incising the skin lift up the subjacent tissues layer by layer and divide them between forceps. The layers spoken of are not the layers described by anatomists, such are rarely recognized and never sought; they are merely such thin sheets of tissue as happen to be picked up by the forceps. The sac is soon reached and may be identified by the presence of subperitoneal fat immediately outside it, by its lead or bluish color and by its gliding over the contents beneath it. In small herniæ it may be difficult to find the sac unless one first exposes the parietal peritoneum at the hernial aperture and follows the peritoneum into its prolongation, the sac.

2. If the hernial aperture constricts the hernia, divide the constriction by cutting from without inward. This is generally much easier and safer than the old method of passing a specially devised knife through the ring and making a number of nicks in it from within outward. In some hernia, however, the older method may still occasionally be the better.

3. Open the sac, examine its contents and if necessary treat them.

(*a*) There is redundant omentum. Apply a row of interlocked ligatures to the omentum and cut away the excess tissue. Before ligating spread out the omentum and examine carefully lest some loop of intestine be hidden among its folds.

(*b*) The omentum is adherent to the sac. Either ligate and divide the omentum above the adhesion, leaving the adherent portion to be removed while the sac is being treated, or separate the adhesions and reduce the omentum.

(*c*) The omentum is gangrenous or much inflamed. Excise it at a safe distance from the lesion, if necessary pulling some fresh omentum out of the abdominal cavity so as to apply the ligatures on healthy tissue. If infection is extensive and severe it is wise *not* to reduce the stump after excision but to drain. *As* an alternative method carefully protect the exposed gangrenous mass, put on fresh gloves, use fresh instruments, sterilize the abdomen again, open the abdomen, expose the inner end of the hernial aperture, protect the peritoneal cavity with gauze pads, ligate and divide the omentum as it enters the hernial aperture, if possible divide the neck of the sac and suture the resultant peritoneal wound, close the abdomen and apply dressings. Now attack the disease through the original incision, removing disease and providing free drainage.

(*d*) The intestine is adherent to the sac or to omentum.

If the adhesions are soft, they are easily separated by finger or gauze dissection and should then be smeared with vaseline as this *may* possibly prevent their re-formation. If they are firm they may require sharp dissection which must be done at the expense of the less important structures. If the gut wall is injured, it must be repaired. Remember that a moderately extensive but shallow impairment of the integrity of the gut wall can be repaired by covering it with a patch of healthy, thin omentum or even of fascia. String-like adhesions should be divided close to the gut, ligatures being used if required. If the intestine is extensively injured during the above procedures, enterectomy may be necessary.

(*e*) Stricture of the intestine may have developed owing to prolonged pressure from the hernial aperture or sac neck. If necessary, treat the stricture by an operation similar to the Heinecke-Mikulicz pyloroplasty or short circuit the bowel.

(*f*) The intestine is uniformly plum-colored, much congested, flaccid and swollen but is not frankly gangrenous. At the site of constriction the gut wall is thin and looks as if composed of serosa alone but that serosa is not eroded. After all constrictions have been relieved, pull a little more of the intestine out of the abdomen, lay the prolapsed bowel on warm moist gauze, gently douche with warm water and closely observe if the circulation reëstablishes itself and the gut wall resumes its tonicity. If this happens, reduce the hernial contents.

(*g*) A limited area of intestine is frankly gangrenous. Invaginate this gangrenous area by means of Lembert sutures; it will soon slough into the bowel cavity.

(*h*) There is extensive gangrene of the intestine. Veau writes (Pratique courante Chir d'urgence, p. 107): "In these conditions, a real surgeon resects the diseased loop, makes an anastomosis and reduces everything. The patient is completely cured (perhaps?)."

Very often in skilled hands the above procedure is the method of choice, but Veau's "perhaps" is distinctly *à propos*. Unfortunately a large number of patients are in such a critical condition that any elaborate operation is out of the question. Under such circumstances it is wise to establish an artificial anus at the site of the hernia but in so doing one must be sure that the afferent segment of gut is sufficiently patent to admit of the free escape of the intestinal contents. At the same time one ought to *preserve* the adhesions between the gut and the hernial ring to prevent contamination of the abdominal cavity. Rose

and Carless advise dilating the strictured gut and ring when necessary by means of the finger or forceps passed up inside the gut. Subsequently the fæcal fistula may be closed and the continuity of the bowel reëstablished. In some cases of strangulated hernia (especially of the femoral variety) it is wise, first to expose and inspect the hernia from below, and second to open the abdomen, protect the general peritoneal cavity with gauze pads, reduce the hernia into the abdominal cavity and treat the gangrenous segment of gut as one would treat any similar intra-abdominal lesion.

4. Treatment of the sac. As a congenital or acquired protrusion of the peritoneum through a hiatus in the essential belly wall constitutes a potential hernia, removal of the protrusion and prevention of its re-formation is the aim of the treatment. The methods by which this aim is attained will be described under the operations for the cure of the individual forms of hernia.

5. Closure of the hernial aperture. The principle on which all successful operations for hernia is based is the simple one that it is easier to get firm union between two sheets of paper with mucilage, if their surfaces instead of their edges are brought together. Overlapping of the tissues is the key to the success of Macewen's and Bassini's operations for inguinal and of Mayo's for umbilical herniæ.

Any operation which adheres to this principle is sure to succeed provided there is no excess of tension on the sutures.

6. Irreducible herniæ when neither incarcerated nor strangulated and when operation is contraindicated must be protected with great care. Often a bag-like truss is of value but generally the patients soon learn by experience how to protect themselves. Every surgeon remembers old men with large irreducible herniæ who visit the clinic periodically to have a coincident hydrocele aspirated and who yet seem to live a moderately comfortable life, making complaint not of the hernia but of the annoyance of the hydrocele.

7. Large irreducible herniæ. Occasionally herniæ become so large and contain so many organs that these organs may be said to have lost their right of domicile in the abdomen, and hence reduction, whether operative or non-operative, becomes impossible or unjustifiable.

When the trouble is caused by the presence of an undue amount of omental fat it is often possible by prescribing rest in bed, restricted diet, and the exhibition of purgatives to so reduce the herniated mass that a cure by operation becomes possible and safe.

Sometimes adhesions uniting the hernial contents to each other and to the sac constitute a condition which, either alone or in combination with a poor state of health, contraindicate any attempt at reduction. In such cases when strangulation or obstruction becomes evident, what means have we to overcome their disastrous results? If the strangulation is due to constriction at the hernial orifice, common sense tells us to divide the constriction by free, open incision, and, contrary to the practice in "radical cure," to endeavor to retain the increased patency of the opening between the abdominal cavity and the hernial sac. In other words, our aim ought to be to make the abdominal cavity and hernial sac as nearly as possible one.

Usually in large herniæ nature has so dilated the abdominal orifice that strangulation at this point is rare. It is more common to find that adhesions, bands, diverticula, etc., in the hernial sac itself are the cause of strangulation.

As Madelung ("Archiv. f. klin. Chir.," LXXIV, 60) points out, gangrene may be far advanced in herniæ of this class, and symptoms be almost absent; thus during operation one may be compelled to excise a considerable amount of diseased gut, joining the afferent and efferent segments by anastomosis or enterorrhaphy, or one may establish a fæcal fistula. Some surgeons have, on general principles, excised a mass of herniated gut, so that reduction of the remainder became possible and a radical cure could be effected.

In very large herniæ there is always some obstruction to the onward passage of fæces; this obstruction varies from time to time. Mild exacerbations are usually successfully treated by purgation, enemata, rest in bed, massage, etc., but occasionally operative interference becomes necessary. Madelung writes, "In many cases, especially the old and feeble, when coprostasis has continued for a long time, it is very proper to establish a fistula in the afferent gut. Under local anæsthesia this is absolutely without danger even in the most debilitated. The fistula should be small, about the size of a medium-sized Paquelin cautery point. It should drain only part of the intestinal contents, acting as a kind of safety-valve." When the patient is strong enough to withstand a more severe operation, intra-abdominal anastomosis between the afferent and efferent loops of gut serves to segregate or exclude the affected viscera. It is, of course, impossible to formulate precise rules for the operative treatment of irreducible herniæ, but it is hoped the above brief remarks may aid the inexperienced practitioner in an emergency.

1. **Inguinal Hernia.**—*Indirect or Oblique Inguinal Hernia.*—In the male the testicle is developed behind and is united to, the posterior parietal peritoneum. From it a cord passes downward to be attached to the abdominal wall at the apex of a slight pouch of peritoneum (vaginal process) which projects a short distance into the substance of the genital swelling. The cord is the inguinal ligament or gubernaculum testis, in the male; in the female it forms the round ligament and the peritoneal protrusion is the canal of Nuck.

As development proceeds the abdominal walls grow more (Fig. 10) rapidly than does the inguinal ligament and thus the testicle is pulled down toward the lower attachment of the ligament, *i.e.*, toward the inguinal region.

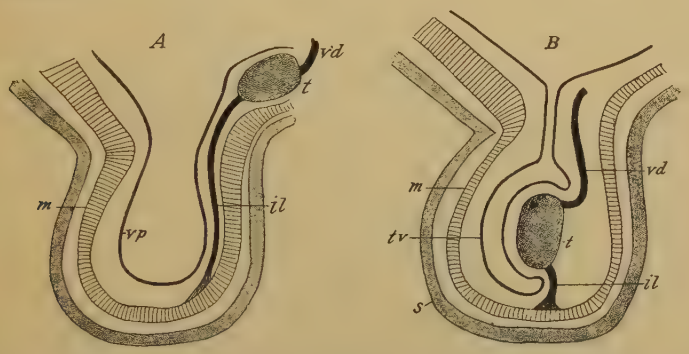

FIG. 10.—Diagrams illustrating the descent of the testis. *il*, Inguinal ligament; *m*, muscular layer; *s*, skin and dartos of the scrotum; *t*, testis; *tv*, tunica vaginalis; *vd*, deferens; *vp*, vaginal process of peritoneum. (*After Hertwig.*)

The vaginal process elongates, pushes further into the genital swelling (the future scrotum) and drags the lower end of the ligament with it. Thus the testicle at first situated behind the peritoneum well up in the abdomen comes to lie in the opening in the essential belly wall through which the vaginal process passes and lastly in the scrotum where it is enveloped in the vaginal process. For some time after birth this condition persists and the testicles are easily pushed up into the abdomen or may be pulled up by the cremaster muscle. Gradually the upper end of the vaginal process becomes narrowed like the neck of a bottle to be ultimately obliterated leaving a peritoneal sac (tunica vaginalis) enveloping the testicle and having no communication with the peritoneal cavity. The testicle in its descent naturally pulls after it its means of nourishment and drainage (arteries, veins, nerves and vas deferens); these are held together by fibrous tissue and constitute the spermatic cord. The fibrous tissue of the cord is derived from the

transversalis fascia. The opening through which the vaginal process traverses the essential belly wall is the inguinal canal.

Surgical Anatomy of the Inguinal Canal.—The inguinal canal is an oblique passage through the essential belly wall and is occupied by the spermatic cord. The cord, passing up from the scrotum, enters a split in the fascia of the external oblique just external to the spine of the pubis (external or superficial abdominal ring). This opening is barely large enough to admit the tip of the finger. The cord now runs a course upward and outward under the fascia of the external oblique until it reaches a point about 1.25 to 2 cm. (½ to ¾ in.) above the middle of Poupart's ligament and about 4 cm. (1¾ in.) from the external ring, where it again changes its course to pass through an

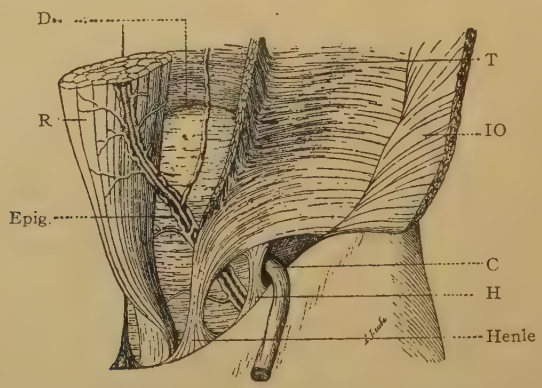

FIG. 11.—*T*, Transversalis muscle; *I.O.*, internal oblique; *R*, rectus; *Epig*, deep epigastric vessels; *D*, Douglas' fold; *C*, cord; *H*, Hesselbach's ligament; *Henle*, Henle's ligament. (*Poirier and Charpey.*)

opening in the transversalis fascia and becomes a subperitoneal, intra-abdominal structure. The transversalis fascia (under various names) is *the* strong continuous fascial subperitoneal lining of the abdominal cavity and all the large vessels in the posterior abdomen lie between it and the peritoneum. These vessels, *e.g.*, the femoral, the spermatic, etc., etc., must perforate the fascia before becoming distributed. Wherever there is such perforation, the fascia is continued downward along the vessels for a short distance to gradually blend with the vessel wall. At the internal abdominal ring the cord perforates the transversalis fascia which sends a prolongation downward along it as the infundibuliform fascia. The lower part of the internal oblique arises from the outer half or two-thirds of the deep surface of Poupart's ligament and its fibers arch downward and inward over the spermatic cord (or round ligament of the uterus) and end in tendinous fibers common to them

and the lower part of the transversalis muscle (the conjoined tendon) to be inserted in the front of the pubis and the inner part of the iliopectineal line, behind Gimbernat's ligament. The conjoined tendon at its insertion is often divided into an outer portion Hesselbach's ligament and an inner Henle's ligament. The relation of the inferior epigastric vessels to Hesselbach's ligament is well shown in Fig. 11.

The inguinal canal has thus an anterior and posterior wall, a roof and a floor. The anterior wall consists of the fascia of the external oblique and for its outer third, the internal oblique.

The posterior wall is formed by the transversalis fascia and at the inner end by the conjoined tendon. The roof is formed by the arching fibers of the internal oblique. The floor is Poupart's ligament on which the cord lies. The deep or inferior epigastric artery runs upward between the peritoneum and the transversalis fascia internal to the internal ring and external to the external ring.

Ferguson and others have shown that the origin of the internal oblique from Poupart's ligament is often faulty so that frequently that muscle takes no part in the formation of the anterior wall of the inguinal canal and hence leaves the canal weak, especially opposite the internal ring where weakness is most detrimental.

It is easy to see how weakness of the essential belly wall is always present at the inguinal canal and how various anomalies of structure may accentuate that weakness. It is also very easy to understand that when the vaginal process of the peritoneum fails to become obliterated in the normal manner, numerous forms of inguinal herniæ may result as well as hydroceles of the cord. Any hernia which leaves the abdomen by the internal ring and accompanies the cord for a greater or less distance is called an oblique inguinal hernia. It would be a waste of time and space to endeavor to describe all the varieties of oblique inguinal herniæ.

Scrotal Hernia.—An inguinal hernia which enters the scrotum (Figs. 12 and 13).

Labial Hernia.—About 60 per cent. of herniæ in the female are inguinal (Coley). Usually the hernia is small, being confined to the inguinal canal or protruding to a slight extent through the external ring. Occasionally, however, it passes down into the labium where it forms a tumor. The symptoms are those of inguinal hernia and the treatment is the same as in the male but from evident anatomic reasons it is much easier and even more successful.

Bubonocele.—An inguinal hernia which does not protrude through the external abdominal ring (Fig. 14).

Interparietal or Interstitial Hernia.—Instead of passing through the inguinal canal the hernia may insinuate itself between the layers of the abdominal wall or while part of the hernia may pursue its usual course toward the scrotum it sends a diverticulum between the layers of the parietes, thus forming a bilocular interparietal hernia (Figs. 15 and 16). The chief varieties of interparietal hernia are:

FIG. 12.—Scrotal hernia.

(*a*) Properitoneal (Fig. 17). The hernia lies between the peritoneum and the transversalis fascia.

(*b*) Interstitial inguinal hernia. The hernia lies between the internal and external oblique muscles (Fig. 18).

(*c*) Superficial inguinal hernia. The hernia has come through the external ring but instead of following the cord into the scrotum it has formed for itself a subcutaneous cave (Fig. 19).

All these forms of interparietal hernia are often bilocular (Fig. 16).

Sliding Hernia; Adherent Hernia.—Occasionally in operating on inguinal hernia one may find a sac situated in front of and internal to a loop of large intestine (cæcum or sigmoid) which seems to lie in whole or in part outside the sac. In other cases the sac may apparently be absent. An easy and seductive explanation of the occurrence of sliding

FIG. 13.—Scrotal hernia.

hernia is that a portion of large intestine covered on but one side by peritoneum and lying near a hernial aperture slides into the aperture (Fig. 20). The large intestine is primarily completely covered with peritoneum and is provided with a mesentery. Before birth, the posterior surfaces of the mesentery of the ascending and descending colons become applied and fused to the posterior parietal peritoneum and the

FIG. 14.—Bubonocele.

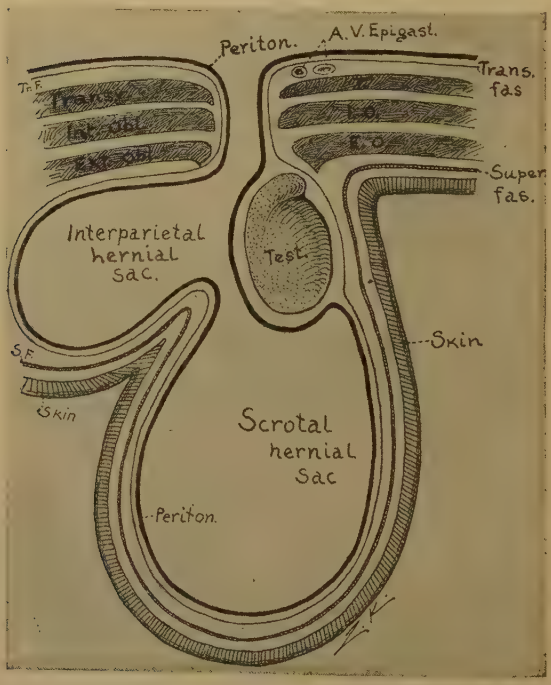

FIG. 15.—Bilocular hernia. (*Schrager, Surg., Gyn. & Obst.*)

posterior surfaces of these intestines themselves are similarly fused to the parietes. Thus normally these intestines are fixed and cannot be-

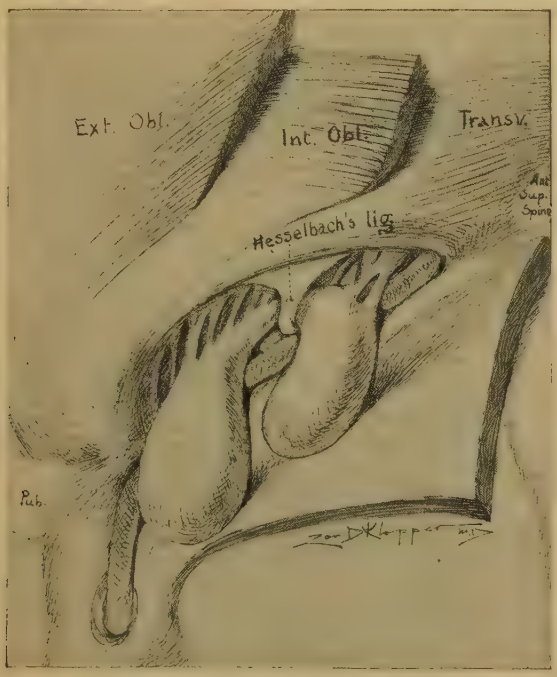

FIG. 16.—Biloculation of a hernial sac by a strongly developed Hesselbach's ligament. (*Schrager, Surg., Gyn. & Obst.*)

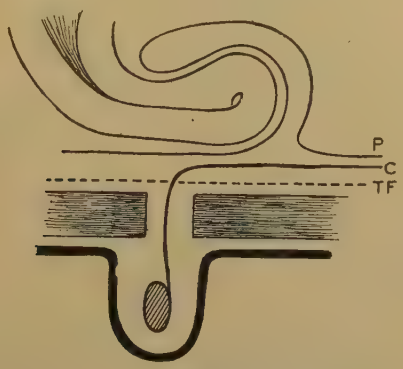

FIG. 17.—Properitoneal hernia. *P*, Peritoneum; *C*, cord; *T.F.*, transversalis fascia.

come herniated. But the fusion is often incomplete so that any part of the colon may have a mesentery, may be very mobile and may become

herniated. As Lardennois and Okinczyc write) Journ. de Chir., Sept., 1909): "If the cæcum and ascending colon form the contents of a hernia it is because they are mobile, due to arrest of normal morpho-

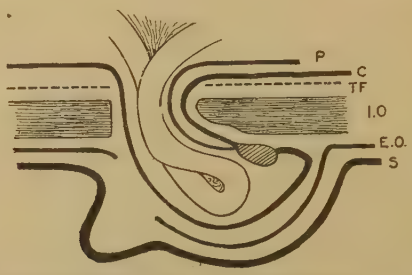

FIG. 18.—Interparietal or interstitial hernia. *P*, Peritoneum; *C*, cord; *T.F.*, transversalis fascia; *I.O.*, Int. oblique; *E.O.*, Ext. oblique; *S*, skin.

genesis of the peritoneum and failure of coalescence; as the normally mobile small intestine can enter a hernial sac, so also can the abnormally

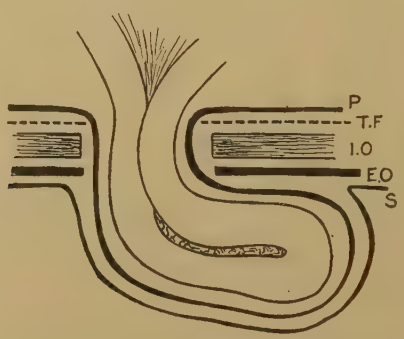

FIG. 19.—Superficial inguinal hernia.

mobile large intestine. In a word, the whole pathology of herniæ of the large intestine rests on the pre-existing abnormal mobility of the ileocolic

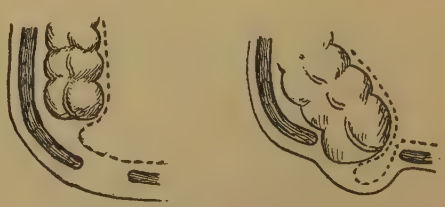

FIG. 20.—Sliding hernia.

loop" (the authors are discussing hernia of the cæcum specially). "If in the immense majority of cases we find the ileocolic loop fixed in the

sac and as Scarpa has well said, 'by the same peritoneal folds which normally fix it in the right flank,' this only means that the loop, primarily free and mobile, has at last found in the sac conditions favorable to the completion of its normal peritoneal morphogenesis."

Ranoshoff (Annals of Surg., Aug., 1912) presents similar views.

Fig. 21 shows an anatomical preparation of a sliding hernia in which the dissector has separated the normal adhesions existing between the posterior (peritoneal) surface of the ileo-cæco-colic loop with its meson

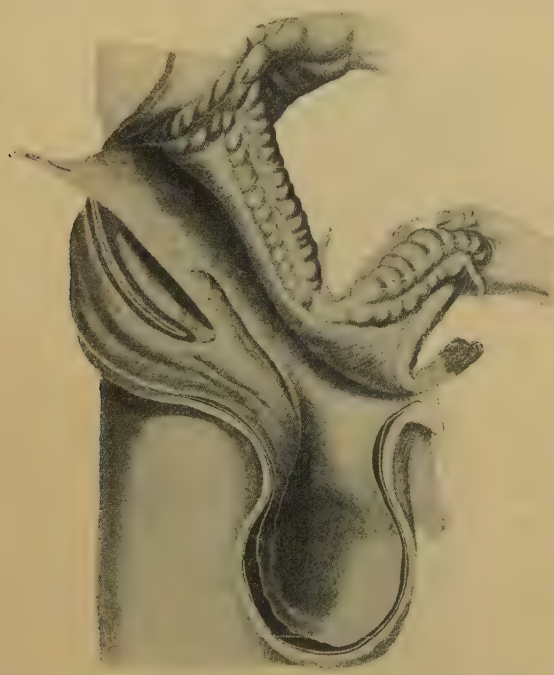

FIG. 21.—Showing the complete sac and the intestines apparently covered with serosa. (*Lardennois and Okinczyc, La Pr. Med.*)

and the parietal peritoneum. He has thus reëstablished the primitive mobility of the loop and demonstrated the existence of a complete where there had appeared a very incomplete sac.

Fig. 22 shows the hernia in its relation to the apparently incomplete sac before mobilization.

Leriche (La Pr. Med., June 18, 1910) corroborates the above views. The author saw a left oblique inguinal hernia of three months' duration in a man of 60. Operation demonstrated it to be of the sliding variety. To this case the Lardennois theory cannot apply. Probably no one explanation is applicable to all cases. It is obvious that in an

adherent or sliding hernia the ordinary methods of "radical cure" are entirely inapplicable as the sac cannot be treated in the usual manner. In cases of "sliding" hernia of the sigmoid, Hotchkiss (Annals of Surg., Aug., 1909) operated as follows: "Having freed the sac from the cord to its full extent, the sac is opened anteriorly and its reducible contents replaced within the abdomen, and held there by a gauze pad. The incision in the sac is then prolonged upward to the internal ring and downward nearly to the lowermost point of attachment of the mesosigmoid on its posterior wall, which permits easy eversion of the sac wall.

FIG. 22.—(*Laridennois and Okinczyc, La. Pr. Med.*)

Grasping the adherent sigmoid and pulling it gently forward, it will be found that the peritoneum of the split hernial sac will become everted in such a manner as easily to form a new and elongated mesentery for the sigmoid, with its smooth peritoneal surfaces turned outward to form its free surface, and its outer or non-peritoneal surfaces falling in contact. Suturing the edges of this new mesentery together permits its elongation to an extent sufficient to allow the perfect reduction of the sigmoid into the abdominal cavity."

"When this step has been accomplished the somewhat irregular-shaped opening into the abdominal cavity may be sutured tightly by a

purse-string suture introduced from within, or by any other form of suture which seems best to meet the case."

"The first case operated upon by this method was reported well after about three years, and, as far as I know, has had no return of his trouble, although he has now a hernia on the other side."

Fiaschi (Australian Med. Gazette, Nov. 20, 1907) recommends colopexy in addition to direct operation on the hernia.

FIG. 23.—The hernial contents. Internally the terminal ileum adherent by its mesentery to the posterior wall of the sac. The cæcum, appendix, and ascending colon are completely adherent to the posterior wall of the sac. A thickening of the visceral serosa covers them and gives the appearance of an incomplete precæco-colic sac. (*Lardennois and Okinczyc, La Pr. Med.*)

In cases as extensive as that shown in Fig. 23 it would be wise to open the abdomen freely by extending the ordinary hernia incision upward and outward and so freely expose the structures to be mobilized.

Direct Inguinal Hernia.—At the external inguinal ring the fascia of the external oblique is of course absent; hence this is a weak spot in the essential belly wall. A pouch of peritoneum may penetrate between the outer edge of the rectus muscle and the deep epigastric artery (Hesselbach's triangle) carrying in front of it the conjoined tendon or

passing between Hesselbach's and Henle's ligaments. It reaches the lower part of the inguinal canal and may emerge through the external ring. If any viscus enters this sac the result is a direct inguinal hernia. Most surgeons believe such herniæ are always acquired, Murray is probably correct in considering that they are congenital. Direct inguinal herniæ usually occur in adults and are frequently bilateral. They rarely reach into the scrotum, may remain in the inguinal canal (bubonocele) and are rarely of large size. While in oblique hernia the cord lies behind the hernia, in the direct variety it is anterior or is spread out over the front of the sac.

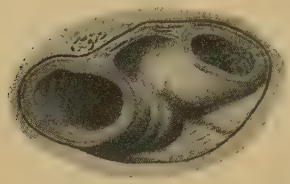

FIG. 24.—Showing the true relationship between the sac and the intestine. The black line represents the complete sac. (*Lardennois and Okinczyc, La Pr. Med.*)

Dean Lewis when operating on a direct hernia found two sacs, one on each side of Hesselbach's ligament (Fig. 16). Fig. 26 shows the simultaneous presence of a direct and an indirect hernia.

Symptoms of Oblique Inguinal Hernia.—Generally local swelling is the first thing to notify the patient that anything is amiss, or the condition may be discovered during a physical examination. A feeling of weakness in the inguinal canal which often leads the patient to support

FIG. 25.—Showing Hesselbach's ligament. (*Schrager, Surg., Gyn. & Obst.*)

that region with his hand during straining is often present but the subject has become so accustomed to this sensation that it makes no impression on him until after he has undergone a successful operation when its *absence* strikes him forcibly. Vague pains and a sense of dragging may cause complaint.

Method of Examination.—(1) While the patient is standing, palpate the scrotum and inguinal region to discover any swelling. (2) Put the end of the little finger on the skin of the scrotum. Push the

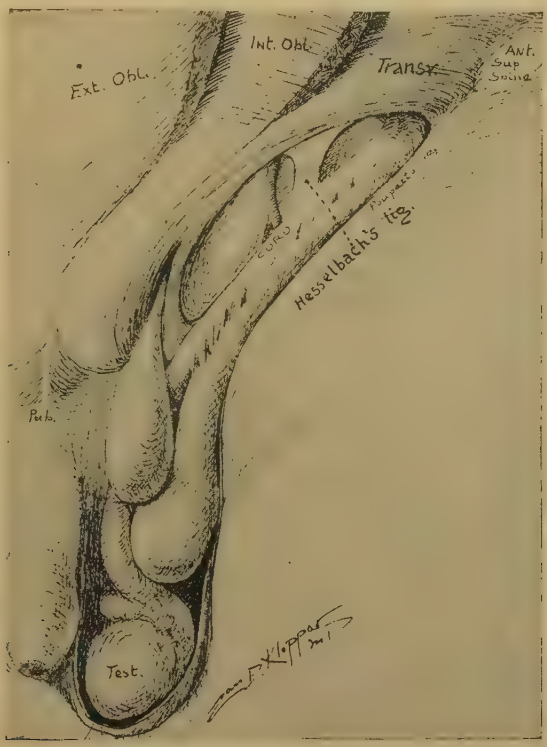

FIG. 26.—Double hernia sac. (*Schrager, Surg., Gyn. & Obst.*)

finger upward following the cord until it impinges against or enters the external (superficial) inguinal ring. Note the size of the ring and if anything other than the cord is contained in it. Make the patient cough and note if there is any "impulse on coughing." (3) If there is a swelling in the scrotum make the patient lie down and try to reduce the swelling by manipulation. If reduction is possible the diagnosis is easy, especially if the reduction is accompanied by gurgling.

It is important to palpate the upper part of the swelling and note

if it lies *above* Poupart's ligament and if it has reached the external ring internally to the spine of the pubis.

A hydrocele of the tunica vaginalis does not extend up into the inguinal canal unless the funicular process is patent (a condition of potential hernia). The translucency test usually easily distinguishes a hydrocele (in infants the intestine is also translucent). (4) If the hernia does not emerge from the external ring (bubonocele) and is not reducible it must be distinguished from (*a*) glandular swellings. These are lobulated, increase in size rapidly, tend to suppurate and have no impulse on coughing.

(*b*) Encysted hydrocele of the cord. Small, elastic. No impulse on coughing. Translucent.

(*c*) Retained testis. Characteristically tender.

(*d*) Tumors of the cord or canal (lipomata, fibromata, etc.). These are rare and no rules can be laid down for their recognition.

(*e*) Femoral hernia. The neck of the hernia is below Poupart's ligament and is external to and below the spine of the pubis.

The treatment of inguinal hernia and of most of the conditions with which it may be confused is very similar.

Symptoms of Direct Inguinal Hernia.—These are almost the same as in the oblique variety except that the examining finger seems to pass directly through the abdominal wall. It must be remembered, however, that in infants there is no great obliquity to the inguinal canal and that in cases of old and large oblique herniæ the internal and external rings become superimposed. In some cases only during operation can the two varieties be differentiated.

Properitoneal and *interstitial herniæ* present symptoms similar to those of bubonocele and when they are irreducible or strangulated, diagnosis is frequently impossible except during operation.

Operations for Inguinal Hernia.—*Macewen's Operation.*—1. Make an oblique incision about 3 in. in length over the external abdominal ring. Practically, a good rule is to begin the cut 1 in. above and to the outer side of the upper limit of the hernial swelling and continue the incision downward and inward over the hernial neck. Expose the upper part of the sac of the hernia.

2. By blunt dissection free the sac from its surroundings and from the spermatic cord, which lies posteriorly. This must be done thoroughly.

3. Reduce the contents of the sac and then open and inspect it.

It is often necessary to open the sac before the hernia can or ought to be reduced.

4. Pass the finger outside the sac through the opening in the parietes and separate the peritoneum (of which the sac is a mere continuation) from the parietes for a space of ¾ in. on every side of the opening (Fig. 27).

5. Should the sac be too voluminous, cut off its distal end, which may be removed or left in the scrotum. Every time it is necessary to make an incision in the sac the position of the cord should be ascertained.

6. A stitch of chromicized catgut is taken through the distal extremity of the sac, which is now hanging loosely through the abdominal wall (Fig. 28), and is there tied. The long end of the suture is passed

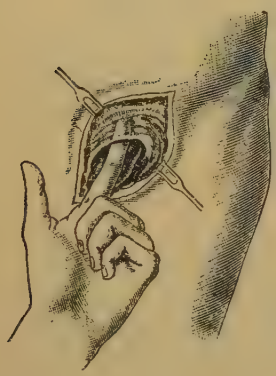

FIG. 27.—Macewen's operation. (*Esmarch and Kowalzig.*)

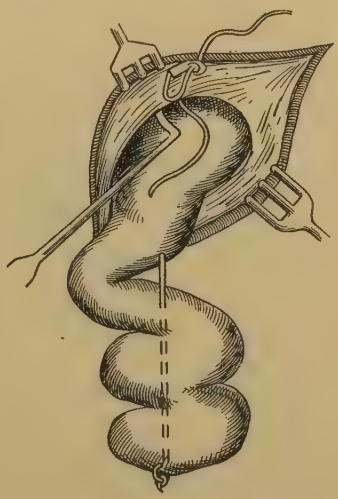

FIG. 28.—Treatment of sac.

three or four times from side to side through the sac, so that when pulled upon, it throws the sac into folds. The loose end of the thread is threaded on a Macewen hernia needle. The needle, guided by the finger, is passed up external to the sac through the abdominal opening, and thrust outward through the whole thickness of the parietes (with the exception of peritoneum and skin). If the thread is now pulled, the sac will be reduced into the belly cavity (external to the peritoneum) and will form a firm, puckered-up pad lying between the peritoneum and the parietes. The end of the thread is caught by a hemostat and temporarily thrown aside.

7. A Macewen hernia needle is passed through the conjoined tendon from without inward, and its point, guided by the finger in the abdominal opening, is carried upward for about ¾ in. and once more passed through the conjoined tendon, this time from within outward (Fig. 29, *a*). By this means a strong chromicized catgut thread is placed in position through the inner wall of the ring.

8. The lower end of the suture is now threaded on an appropriate needle and passed through Poupart's ligament from within outward a short distance above the spermatic cord (Fig. 29, *b* and *c*). The upper end of the suture is passed from within outward through the aponeurosis of the external oblique. We now have a single thread which takes the course seen in Fig. 29, *d*. If one pulls upon the ends of the suture, the tissues external and inferior to the opening (viz., Poupart's

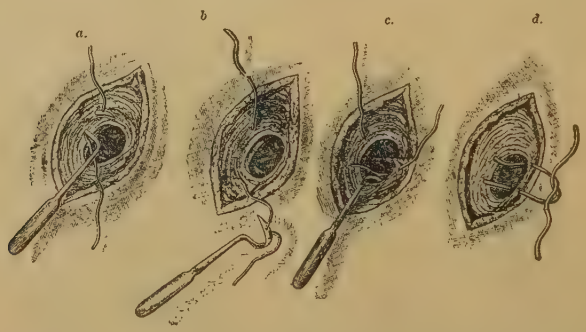

FIG. 29.—Closure of canal. Macewen's operation. (*Esmarch and Kowalzig.*

ligament and the aponeurosis of the external oblique) must slide over those internal and superior (viz., the conjoined tendon), and when the suture is firmly tied, the obliquity of the inguinal canal is restored. The anterior surface of the conjoined tendon is in apposition with the posterior surface of Poupart's ligament.

Before the suture is definitely tied the spermatic cord is examined lest too much pressure be exerted on it.

9. The end of the suture used for puckering the sac is now pulled tight and fixed in the belly wall subcutaneously.

10. The skin wound is closed.

Bassini's Operation.—1. An incision is made parallel to and ½ in. above Poupart's ligament. It begins external to the region of the internal abdominal ring and ends internal to the external ring.

2. A firm aponeurotic sheet (aponeurosis of external oblique) covering the hernia is exposed and divided in the direction of the wound

with scissors or on a director (Fig. 30). Thus are formed a superior and inferior aponeurotic flap. The superior flap is separated from the subjacent tissues for a distance of 1 or 1½ in.

3. The hernial sac now lies exposed from its peritoneal origin to the point where it disappears into the scrotum, and is recognized according to the rules described on p. 25. By blunt dissection the sac is separated from its surroundings and from the spermatic cord. This must be done thoroughly and carefully. The sac should be opened and its contents reduced or treated according to the usual methods.

4. Downward traction being exerted on the sac, its neck is transfixed and ligated as high up as possible, and the distal portion cut off. The stump should retract into the belly cavity and be lost to sight.

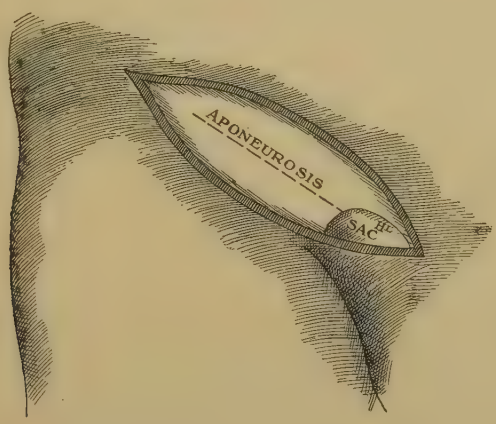

FIG. 30.—Bassini's aperation.

Sometimes the neck of the sac is so bulky or of such a shape that ligation is impossible. In these cases the neck of the sac is sewed up and the distal portion removed. By whatever method the neck is closed and divided, special attention ought to be paid to the position of the spermatic cord, as this important structure has frequently been injured. Separation of the sac from its surroundings has freshened all the tissues so that if placed in apposition they will unite.

5. The spermatic cord is raised from its bed and held out of the way by a blunt hook. Review of the wound now shows that its upper edge consists of three layers: (*a*) A deep thick layer, marked muscular flap (Fig. 31) (internal oblique and transversalis muscles, transversalis fascia, and external margin of the rectus); (*b*) superior aponeurotic flap (aponeurosis of external oblique); (*c*) the skin.

The lower edge of the wound consists of the deep layer of Poupart's

ligament on which the spermatic cord normally lies, the inferior aponeurotic flap, and the skin.

6. A suture is now passed through the muscular flap (Fig. 32) close to the exit of the cord from the abdomen, and unites it to the deeper layer of Poupart's ligament. This suture must be so placed as to close the wound beside the cord, but yet not interfere with its circulation. Some surgeons place a suture external to the cord at the point marked x,

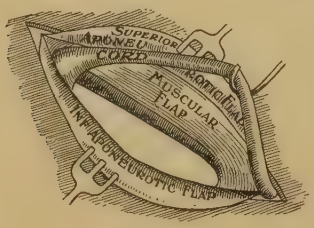

FIG. 31.

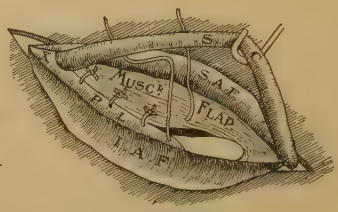

FIG. 32.

FIGS. 31 AND 32.—Bassini's operation.

Fig. 32. This is important. The whole edge of the muscular flap (Figs. 31 and 32) is stitched to the deep layer of Poupart's ligament.

7. The cord is now laid on the top of the line of suture and the superior and inferior aponeurotic flaps united over it (Fig. 33).

8. The skin wound is closed.

Moschcowitz has shown that while the classical Bassini operation is particularly applicable to direct inguinal hernia yet in the oblique variety it is better not to transplant the cord.

One may advantageously modify step 6 of the Bassini operation as follows: Let the cord lie in its normal position; suture the edge of the muscular flap to the deeper layer or shelf of Poupart's ligament in front of the cord. Continue this suture up to the point where the cord must emerge from the external ring. Close the wound in the fascia of the external oblique. Close the skin wound.

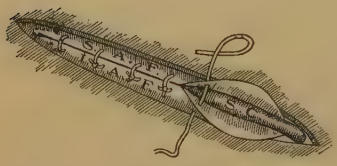

FIG. 33.—Bassini's operation.

In any operation for inguinal hernia (especially direct) the urinary bladder is apt to be pulled into the wound while the hernial sac is being freed and care must, of course, be taken to avoid injuring it.

In old herniæ with wide abdominal apertures, especially when the trouble has recurred after an unsuccessful operation, several means to reinforce the lines of suture are available. (*a*) One may excise

from the thigh a sheet of fascia lata of suitable size, spread it over the lines of suture like a patch and fix it there with a few stitches. (*b*) One may mobilize the upper part of the sartorius muscle (Bloodgood), form it into a flap with pedicle above, lay it over the inguinal region and fix it there with stitches. (*c*) A flap of the aponeurosis over the rectus muscle may be dissected up and thrown over the line of suture. (*d*) The line of suture may be reinforced by a filigree of fine silver wire as advocated by Phelps and Bartlett and strongly recommended by Barker.

Fig. 34.—(*Seelig and Tuholski, Surg., Gyn. & Obst.*)

Femoral Hernia.—*Surgical Anatomy.*—Poupart's ligament stretches from the anterior-superior iliac spine to the pubic spine. It is the thick lower border of the aponeurosis of the external oblique and its superficial part is continuous with the fascia lata of the thigh. Near the insertion of the ligament into the pubic spine and iliopectineal line, a small strong triangular sheet of tissue (Gimbernat's ligament) is given off from it and is directed horizontally backward (the subject being erect) to be inserted into the iliopectineal line (Fig. 34). Externally,

Gimbernat's ligament presents a sharp sickle-shaped edge and inferiorly it is continuous with the fascia lata by means of Hey's ligament. The iliopectineal line is covered by a thick fascial bundle (Cooper's ligament, Fig. 34) which is of great value to the surgeon when endeavoring to close the femoral canal with sutures.

Between Poupart's ligament and the pelvis the following structures emerge from the abdomen into the thigh, all of them beneath the fascia lata; (1) the iliacus muscle, (2) the psoas muscle, (3) the anterior crural nerve between and upon these two muscles, (4) the femoral artery, (5) the femoral vein. Fibrous partitions passing from Poupart's ligament to the bone separate the muscle from the artery and the artery from the vein. To the inner side of the vein a similar partition is present and between this and Gimbernat's ligament is an opening (the femoral ring) which normally contains more or less fat and lymphatics. The femoral ring is one of the notoriously weak points on the abdominal wall. The transversalis fascia sends a funnel-shaped prolongation under Poupart's ligament to surround the femoral vessels as a sheath. The long saphenous vein passes up the inner, anterior surface of the thigh superficial to the fascia lata until it reaches a point immediately below the inner end of Poupart's ligament. Here it perforates the fascia to reach the femoral vein. The perforation constitutes the saphenous opening which is oval with its long axis vertical and is about 1½ in. long by 1 in. wide. The inner border of the opening is indefinite because here the fascia passes behind the iliac vessels to become continuous with the iliac fascia and to cover the horizontal ramus of the pubis. The outer border of the opening is crescentic and curves upward and inward over the great vessels to pass, as Hey's ligament, into Gimbernat's ligament. The saphenous opening is covered by a thin cribriform fascia.

When a pouch of peritoneum passes through the femoral ring, a potential hernia exists. The hernia, having penetrated the ring, forms a passage for itself (the femoral canal) to the saphenous opening where it follows in the direction of least resistance, *i.e.*, it pushes through the delicate cribriform fascia and becomes subcutaneous. The subcutaneous tissues are closely adherent to the lower margin of the saphenous opening; hence if the hernia increases in size, the bulk of it extends outward toward the ilium, assuming more or less of an oblong form, with its long axis parallel to Poupart's ligament (crural arch). The coverings of a femoral hernia are the sac, the transversalis fascia

(fascia propria), the cribriform fascia, subcutaneous tissue and skin. Most of these become indistinguishably fused together.

The course of the hernia being angular and the sharp edge of Gimbernat's ligament being rigid, strangulation is very common. Femoral hernia is proportionally more common in women than men. The symptoms of femoral hernia are those of hernia in general. It is not always easy to distinguish femoral from inguinal herniæ which have not reached the scrotum. If, on careful palpation of the hernial neck, one finds it situated below Poupart's ligament and below and external to the pubic spine the diagnosis of femoral hernia is sure.

Femoral hernia may also be simulated by (1) psoas abscess which, however, usually points external to the femoral vessels. Careful examination of the vertebral column and attention to the history of the case usually make diagnosis easy. Steady pressure on the abscess may cause it to become less prominent, the prominence returning when pressure is removed even without any increase in intra-abdominal pressure or change in the posture of the patient.

(2) Varicose veins. Pressure on the distended vein promptly makes the swelling temporarily disappear. The swelling has a bluish appearance.

(3) Adenitis. Enlarged glands in the femoral region may be indistinguishable from a hernia except that the latter has a palpable pedicle passing into the canal.

(4) Lipomata. A subserous lipoma protruding thr ugh the canal may be indistinguishable from a hernia but this is of little importance as the lipoma may drag a pouch of peritoneum after it through the canal, and so give rise to a potential or an actual hernia.

When femoral hernia is easily reduced by taxis, it may be kept reduced by means of a truss. Trusses for femoral hernia are more annoying to the wearer than are those for inguinal hernia and a properly devised and executed operation is almost invariably curative; hence operation should be advised unless contraindications exist. When strangulation or incarceration is present operation is imperative and must not be delayed.

Operative Treatment.—*Radical Cure.*—Bassini's operation is the one usually chosen, but it may, perhaps, be improved by adding to it Macewen's method of utilizing the sac to form an intra-abdominal pad.

Step 1.—Make an incision 3 in. long, parallel to and below Poupart's ligament (Fig. 35). The center of this incision corresponds to the center of the hernial swelling. Divide the tissues layer by layer be-

tween forceps until the sac is reached. The superficial fascia may be surprisingly thick and fatty.

Step 2.—By blunt dissection free the sac from its surroundings.

Step 3.—Open the sac and reduce its contents.

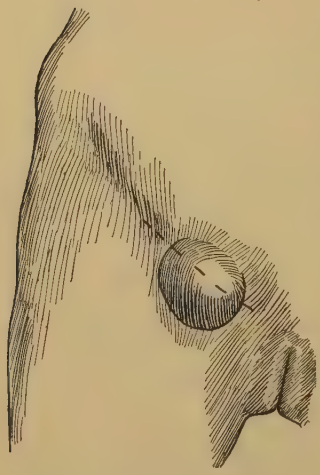

FIG. 35.—Incision femoral hernia.

Step 4.—(*A*) Bassini, having separated the sac from its surroundings up to its junction with the parietal peritoneum (of which it is a mere process), transfixes and ligates it at this point and cuts away the peripheral portion. Many surgeons close the external wound and terminate the operation at this point.

(*B*) Macewen, having separated all the sac from its surroundings, pushes his finger through the femoral opening outside the sac and separates the parietal peritoneum from the parietes for a distance of ¾ in. above the opening. He then treats the sac exactly as in his operation for inguinal hernia, making it into an intra-abdominal pad.

Step 5.—*Bassini's method.* Make a careful survey as to the position of Gimbernat's ligament, Poupart's ligament, the plica falciformis, and the pectineal fascia. Retract the plica falciformis upward and outward. With a fully curved needle introduce the suture A–A

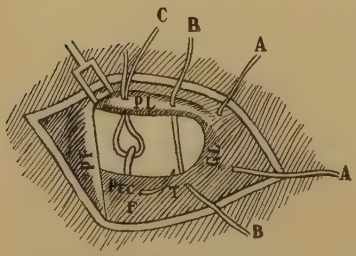

FIG. 36.—Bassini's operation.

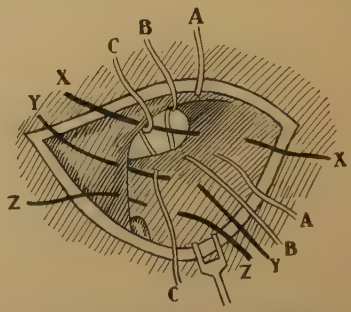

FIG. 37.—Bassini's operation.

(Fig. 36) through the inferior and posterior part of Poupart's ligament and the pectineal fascia close to the pubic spine. About ¼ in. external to A–A introduce the suture B–B. In the same way the suture C is introduced and ought to lie about ½ in. internal to the

femoral vein. The sutures A, B, and C are left for the present without being tied.

Step 6.—The plica falciformis is stitched to that portion of the pectineal fascia which normally forms the posterior wall of the femoral funnel. The insertion of these stitches is shown in Fig. 37 (x–x, y–y, z–z).

Step 7.—The sutures A–A, B–B, C–C, are tied. This approximates Poupart's ligament to the fascia covering the horizontal ramus of the pubis. The sutures X–X, Y–Y, Z–Z are tied. This slides the plica falciformis inward to its normal position or to an exaggeration of its normal position, and completes the closure of the canal. The long saphenous vein is left to dip unmolested under the inferior end of the plica falciformis. (N.B. Sutures A–A, B–B, C–C close the abdominal opening into the femoral canal. Sutures X–X, Y–Y, Z–Z close the canal itself.)

Any operation in which the hernia is approached from below Poupart's ligament is faulty for the following reasons:

(1) The exposure of the abdominal opening of the femoral canal is insufficient to permit the best possible application of sutures.

(2) Space is so limited that procedures such as enterostomy, anastomosis, etc., which may be necessary owing to strangulation, are rendered difficult.

Moschowitz (N. York State Med. Journ., Oct., 1907), Dujarier (Journ. de Chir., Feb., 1912); Lanz (Gaz. d. hop. Par., 1912, No. 38), Seelig and Tuholski (Surg., Gyn. & Obst., Jan., 1914) all recommend very strongly the inguinal route in the treatment of femoral hernia.

Step 1.—Open the inguinal canal as in the Bassini operation for inguinal hernia but prolong the incision slightly over the pubis.

Step 2.—Retract upward the contents of the inguinal canal. Retract downward the inferior flap of the aponeurosis of the external oblique and thus expose Poupart's ligament and the parietal peritoneum. It is now easy to see the neck of the hernial sac (Fig. 38).

Step 3.—Open the peritoneum above the origin of the hernial sac. Reduce and treat the hernial contents from the abdominal side *secundum artem.* If reduction is difficult because of Gimbernat's ligament it is easy to cut its sharp inner margin under guidance of the eye.

Step 4.—*A*. The hernial sac is not adherent to the tissues of the thigh. Pull the sac up into the inguinal canal and treat it as if it was the sac of an inguinal hernia. Close the peritoneal incision.

B. The hernial sac is adherent to its surroundings (this is not very

common). Pass a finger or instrument into the sac and using this as a guide expose and free the sac through an incision in the groin. Treat the sac as if it was part of an inguinal hernia. Close the peritoneal wound.

Step 5.—Close the opening of the femoral canal by suturing Cooper's ligament to Poupart's ligament (Fig. 39). Close the inguinal canal as in Bassini's operation for inguinal hernia.

FIG. 38.—(*Seelig and Tuholski, Surg., Gyn. & Obst.*)

Epigastric Hernia.—The union in the middle line of the mesodermic myotomes which constitute the essential belly wall, is often imperfect and thus above the umbilicus there often exist *transverse* oval or linear lacunæ in the linea alba. Above the umbilicus, subperitoneal fat is often plentiful. If a lobule of this fat escapes through one of the lacunæ and especially if it grows in its new position, it is very apt to drag peritoneum through the lacuna. When this occurs, a potential hernia has been formed and any sudden increase of intra-abdominal

pressure, (cough, sneeze, etc.), can push into it a tag of omentum or a portion of intestine and thus form a true hernia. Omentum is the commonest content of small epigastric herniæ and it is often irreducible. Extruded subserous lipomata are easily distinguished from subcutaneous lipomata by the complete mobility of the latter but to distinguish them from small epigastric herniæ is often an impossibility. When epigastric herniæ become of even moderate size they are easily diagnosed; when

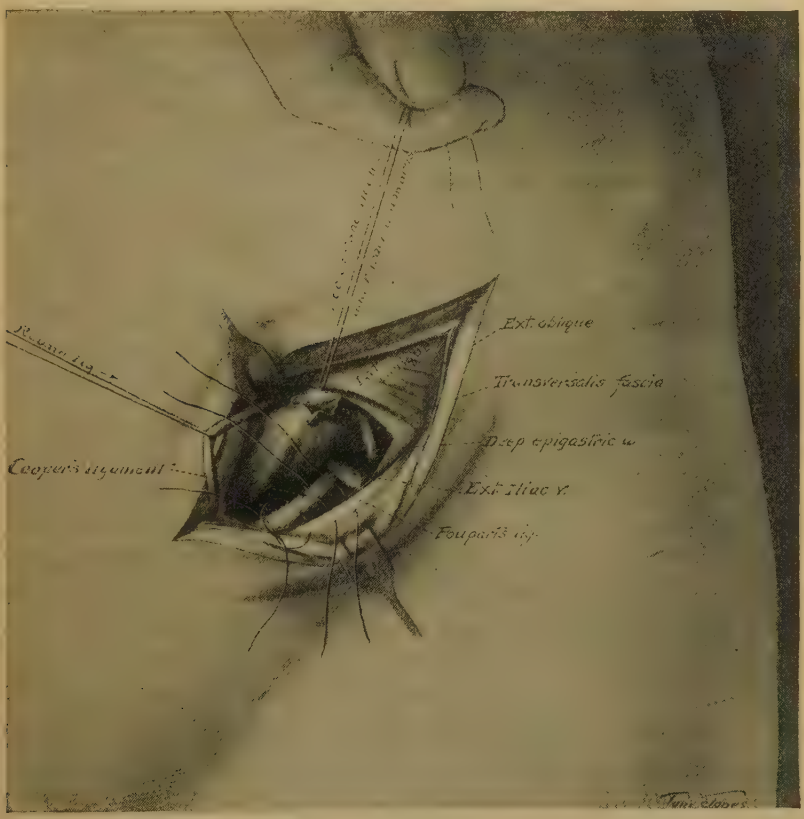

FIG. 39.—(*Seelig and Tuholski, Surg., Gyn. & Obst.*)

small they are often overlooked even when they are actually the cause of distressing symptoms referred to the stomach. As de Quervain writes (Spezielle, Chir. Diagn., p. 282): "If the diagnosis of epigastric hernia was always correctly made, then certain patients would not be treated during years for 'stomach complaint' with the whole arsenal of digestive therapeutics when a harmless operation could at once restore them to health. The dyspepsia of these patients is entirely due

to dragging on the omentum ensnared in the hernial sac. It cannot be too strongly urged that the epigastric region be thoroughly inspected and palpated in every dyspeptic before any 'Tränklein' or special diet is ordered or the stomach tube is used." With these remarks of de Quervain the writer thoroughly agrees.

Treatment.—Expose the sac by transverse or vertical incision. Isolate the sac. Enlarge the hernial aperture. Ligate and divide the neck of the sac or treat the sac by Macewen's method (see inguinal hernia). Close the wound in the essential belly wall by overlapping as in Mayo's operation for umbilical hernia.

Obturator Hernia.—The obturator vessels and nerve pass from the abdomen through a cleft in the obturator internus into a canal (obturator canal) formed by the horizontal ramus of the pubis above and the obturator membrane below. On escaping from the canal, the vessels lie on the external surface of the membrane beneath the obturator externus muscle.

In 279 cadavera Bernstein found three in which a pouch of peritoneum, large enough to admit the index-finger, accompanied the vessels. In two of these (females) the condition was bilateral. Viewed from the abdominal side the hernial opening is situated immediately below the femoral canal (Fig. 3).

When an obturator hernia exists, it passes through the obturator canal, enters the thigh and lies behind the obturator externus and pectineus muscles. Being covered by these muscles, the hernia must attain considerable dimensions before it can be seen or palpated. Pressure of the hernia on the obturator nerve causes pain or paresthesia along the inner side of the thigh as low down as the knee. Movements of the hip-joint are liable to cause pain. The first notable sign of obturator hernia is usually intestinal obstruction and only on operation is the cause of the obstruction found.

The best method of treating a strangulated obturator hernia is to put the patient in the Trendelenburg posture; open the abdomen and protect it with gauze pads; reduce the hernia treating the strangulated gut *secundum artem;* extirpate the hernial sac or, if this is impossible, its neck; close the hernial opening with a few sutures.

It may be advisable in some cases to pass a forceps or the finger through the hernial sac into the thigh and with this as a guide, to expose the sac from the thigh for purposes of drainage or to aid in extirpation of the sac.

Sciatic or Gluteal Hernia.—The gluteal artery emerges from the pelvis through the great sacro-sciatic notch above the pyriformis muscle.

The great sciatic nerve and the sciatic artery emerge through the same notch but below the pyriformis.

The internal pudic artery leaves the pelvis at the lowest part of the great sacro-sciatic notch, winds round the sciatic spine to re-enter the pelvis by the lesser sacro-sciatic notch.

The passage of each of these structures through the pelvic wall leaves a possible weak spot and through these weak spots herniæ may pass.

Herniæ accompanying the gluteal vessels make their appearance *above* the pyriformis muscles; all other sciatic herniæ are below that muscle. All of these herniæ are covered by the gluteus maximus. Sciatic herniæ are extremely rare and usually small.

Perineal Hernia.—From the inner surface of the lateral walls of the true pelvis along a line reaching from the sciatic spine to the pubis, arise the levatores ani muscles and the coccygeus. These muscles run downward and inward to meet in the middle line. Being covered with fascia above and below, they form a hammock-like diaphragm closing the lower outlet of the pelvis completely except where the diaphragm is perforated by the rectum, vagina and urethra. If Douglas' pouch reaches lower than usual (Ebner) and if an opening is formed between the coccygeus and the levator ani or between the muscular bundles of the latter muscles, then a pouch of peritoneum may protrude through the muscular diaphragm and lead to the formation of a hernia.

"A perineal hernia may appear in any of the following forms:

"1. In the male the hernia descends between the bladder and the rectum and causes a protrusion of the skin of the perineum. In the female the hernia develops between the uterus and the rectum, and appears either near the anus or in the posterior portion of one of the labia majora. Such herniæ appearing between the anus and the tuberosity of the ischium will consequently protrude externally, like a sciatic hernia, below the lower border of the gluteus maximus.

"2. The hernia protrudes toward the rectum or vagina and pushes one of these structures in advance of it, so that a prolapse of the organ occurs (the prolapse hernia of Rose). In this manner a rectal hernia or a posterior vaginal hernia may arise.

"3. In the female the peritoneal protrusion may occur in the space

between the uterus and the bladder, so that a prolapse hernia of the anterior vaginal wall (anterior vaginal hernia) is produced.

"In addition to these completely developed forms of perineal hernia, incomplete forms also occur, since the hernia may remain in the ischiorectal fossa or protrude toward the bladder without causing a visible external swelling." (Sultan.)

Umbilical Hernia.—When the body walls of the embryo separate the body cavity from the yolk sac an opening in the body wall persists through which passes the umbilical cord. Up to about the seventh or eighth week of fœtal life intestine is present in the proximal portion of the cord but soon after this the intestine becomes confined to the abdominal cavity. When the cord separates from the body after birth, closure of the abdominal opening normally takes place but it is easy to realize how a pouch of peritoneum may protrude into the scar and constitute a potential hernia. A persistent or patent urachus (remnant of allantois) may add to the weakness of the umbilicus.

Stretching of the abdominal parietes due to ascites or to repeated pregnancies still further predisposes to umbilical hernia. According to Macready (Treatise on Rupture) umbilical hernia occurs with equal frequency in both sexes up to 10 years of age. Between the ages of 10 and 20 it practically never develops in the male and is very rare in the female; while in women between 35 and 50 it is most common. Seventy-three per cent. of umbilical herniæ are in females.

There are three varieties of umbilical hernia:

I. *Congenital or Physiological Hernia of the Cord.*—As already stated, the intestine, early in fœtal life, lies to some extent inside the cord. Instead of later becoming entirely intra-abdominal, part of it may remain domiciled in the proximal part of the cord. This condition is *said* to be rare.

Coley reports that only four cases were observed in a total of 75,000 cases of hernia in the New York Hospital for Ruptured and Crippled. The fact that cleanliness and pressure generally result in rapid cure might make one suspect that the apparent rarity is due to their prompt, proper and successful treatment by the obstetrician and that only exceptionally do they come under the eye of a surgeon, but the statistics of the Munich maternity hospital show them present in but 1 of 5184 children. Hernia of the cord may be so small as only to cause a thickening of the cord near its base or may be so large as to constitute a true evisceration.

When of considerable size, operation may be required. Coley advises removal of the outer layer of Wharton's jelly (this is the covering of the hernia) and closure of the hiatus in the parietes with sutures supported by adhesive strapping.

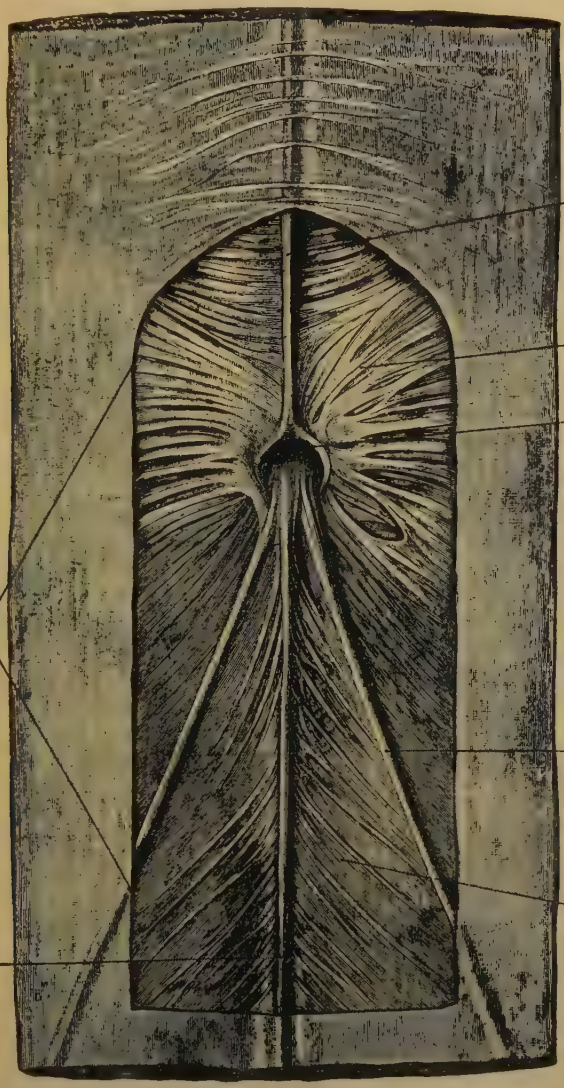

FIG. 40.—Anatomy of umbilicus, posterior view. (*Zuckerkandl.*)

II. *Infantile umbilical herniæ* are those which form at the navel after separation of the cord, during the first year of life; they do not as a rule protrude for some weeks or months after birth.

III. *Hernia of the Adult.*—Distention of the abdomen by fat (or ascites) in the male and in the female by pregnancy aids greatly in the production of hernia at the umbilicus.

Figure 40 shows how the lower part of the umbilical ring is strengthened by the obliterated hypogastric arteries and the urachus so that the weak part of the ring is above these structures. The coverings of an umbilical hernia are often thin and the sac and skin may be inseparably united. In infants the contents are usually intestine; in adults the omentum is almost always present.

The large intestine, especially the transverse colon, is very often among the contents. In very large herniæ almost any viscus may be present. The sac may be simple or may be very irregular and consist

FIG. 41.—Large umbilical hernia in an infant. (*W. B. Coley, in Keen's Surgery.*)

of many compartments. Malgaigne saw a case in which the obliterated hypogastric arteries and the umbilical vein were carried forward by the hernia and produced three grooves on its surface.

Symptoms.—In infants the hernia may be small, rounded or button-shaped and covered by smooth, thin, almost transparent skin on which the umbilical scar is not very noticeable. In other cases (Fig. 41) the hernia is more like the finger of a glove. In adults very small herniæ exist which cause obscure dyspeptic symptoms from dragging on omentum. These are only recognized by carefully inserting the tip of the little finger into the ring and noticing its size and that a small amount of omentum enters it when the patient coughs. Larger herniæ form

rounded or irregular swellings usually contracted at the base. Very large ruptures are pendulous and on their lower part the umbilical scar can be seen. The skin of the pendulous mass where it lies upon the skin of the abdomen is usually macerated by sweat, irritated and may be ulcerated. While the coverings of the hernia are often very thin, yet they may contain a large amount of fat. Some subjects are so atrociously obese that a moderate-sized hernia may be almost completely masked by the surrounding fat. Umbilical herniæ in the young are rarely strangulated and are almost invariably reducible. In adults they are very often irreducible and not infrequently strangulated.

Treatment.—Macready recommends the use of a truss after reduction. He writes, "The propriety of using a large pad or shield is obvious, because a pad adapted to the size of the opening would be liable to constant displacement on the convex surface of the belly. The button or plug in the center of the pad has been condemned by some surgeons lest it should tend to keep the umbilical ring open, but, though I have not observed that it does so, I never use it because there is no certainty that it will keep its place, and because results at least equally good can be obtained without it. The pad should be slightly convex in correspondence with the curve of the abdomen. The truss is more comfortable and more steady if the spring is carried past the middle line behind to the opposite flank, tapering to its extremity, as I have explained in treating of inguinal trusses. A short strap connects the end of the spring with a stud on the center of the pad in front.

In applying an umbilical truss to a child it may be placed nearly in the horizontal plane with the hernial aperture behind the central point of the pad. In adults, however, in whom there is generally some *embonpoint*, the pad should be placed lower, so as to assist in supporting the belly wall below the navel, and the hernial aperture should be just behind the upper edge of the pad. The spring passes around the trunk about midway between the iliac crest and costal arch. When the belly is pendulous, the truss lies in an oblique plane from behind downward and forward."

In children cure generally follows the use of a truss but in adults such treatment is only palliative. As an adult hernia tends to increase in size and to become more complicated as time passes and as operative treatment is uniformly safe and efficient, it is wise to proceed to operation early before conditions prevail which might render treatment

dangerous. In the obese it is wise to endeavor to get rid of much of the objectionable fat by restricting the diet, using saline purgatives, etc.

The Mayo's Operation.—Step 1.—Make transverse elliptical incisions around the umbilicus and the hernia. Deepen these to the base of the hernial protrusion.

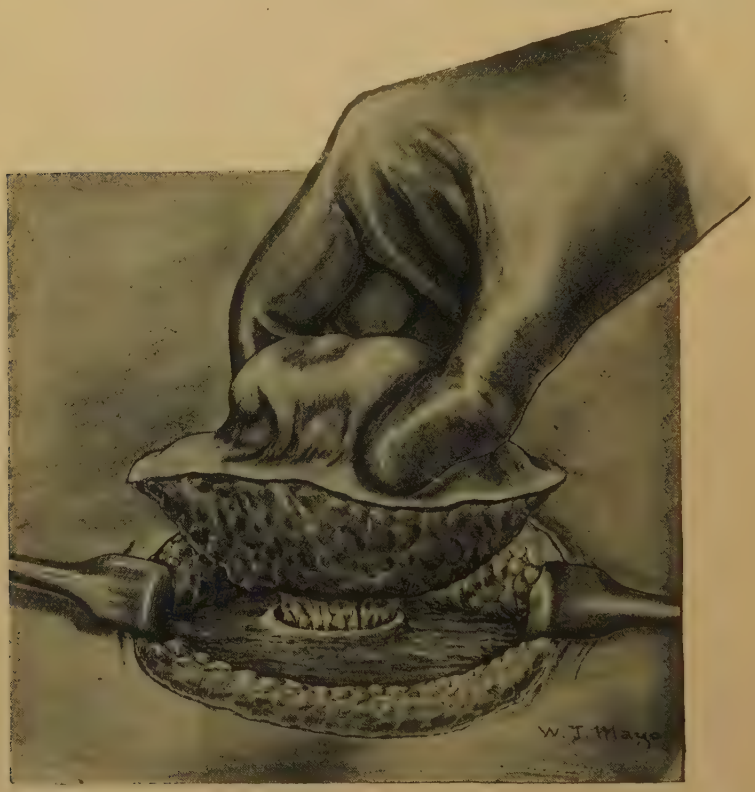

FIG. 42.—Mayo's operation. Umbilical hernia. (*Mayo.*)

Step 2.—For an inch and a half in all directions from the neck of the sac carefully expose the aponeurotic structures (Fig 42).

Step 3.—Divide, in a circular manner, the fibrous and peritoneal coverings of the hernia at the neck. Expose the hernial contents. If viscera are present, separate the adhesions and reduce. Ligate the contained omentum and remove it with the entire sac of the hernia.

Step 4.—Grasp with forceps and approximate the margins of the ring. In whatever direction overlapping proves easiest, lies the proper direction for closure.

Step 5.—Incise the aponeurotic and peritoneal structures of the ring for a distance of 1 in. or more transversely to each side. Separate the peritoneum from the under-surface of the upper of the two flaps thus formed.

Step 6.—Beginning 1 in. or more above the margin of the upper flap, introduce three or four mattress sutures (Fig. 43), the loop firmly grasping the upper margin of the lower flap. Make sufficient traction on these sutures to permit of closure of the peritoneum with a continuous catgut suture. Tie the mattress sutures, sliding or pulling the entire lower aponeurotic flap into the space between the peritoneum and aponeurosis above.

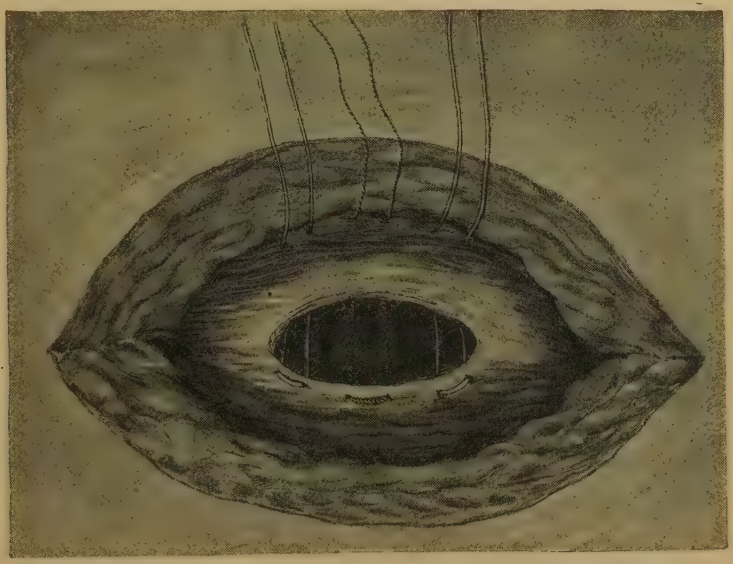

FIG. 43.—Mayo's operation. Umbilical hernia. (*Mayo.*)

Step 7.—With catgut, suture the lower edge of the upper aponeurotic flap to the aponeurosis below (Fig. 44). Close the superficial wound.

When the patient is very fat it is often wise to operate as follows: Make a transverse incision across the abdomen a short distance above the hernia and stretching from flank to flank. Make a similar incision, beginning and ending at the same points, below the hernia running in the fold between the pendulous *abdominal fat* and the *suprapubic* region. Incise deeply enough to expose the aponeurosis. Through both incisions separate the fat from the aponeurosis until the neck of the hernia is reached. Open the sac and treat the contents as already de-

scribed. Remove the skin and fat included between the primary incisions and complete the operation by the Mayo method. Keep the patient in bed not less than two weeks.

Diaphragmatic Herniæ.—Occasionally part of the diaphragm (left half) is so ill developed as to be unable to resist the intra-abdominal pressure and is consequently pushed up into the chest cavity, forming a diaphragmatic eventration. This, on examination by ordinary clinical methods or even by X-rays, may give the impression of being a diaphragmatic hernia.

The diaphragm, being composed of several muscular portions (sternal, costal and lumbar) inserted into a common central fibrous

FIG. 44.—Mayo's operation. Umbilical hernia. (*Mayo.*)

tendon, naturally presents weak points between these various structures. The openings through which the œsophagus, aorta and vena cava pass are also points of weakness (Fig. 45). Congenital defects in the diaphragm, injuries favoring dilatation of the natural weak points or fissures, and wounds are all causes of hernia. Unsutured gunshot and stab wounds of the diaphragm heal badly and hence are very liable to hernia. Lacher's statistics show that of 36 injuries to the diaphragm not submitted to operation 15 died from hernia (or prolapse) within a month and 10 in from 5 to 20 years from the same cause.

The presence of the liver so protects the right half of the diaphragm that hernia is much rarer there than on the left side. Theoretically when a hernia is exposed through the pleura it ought to possess two sacs, one consisting of parietal pleura, the other of peritoneum. Prac-

tically when any sac is present the pleura and the peritoneum are fused but in the majority of cases no sac is present and the condition is, strictly, one of the false hernia.

Herniæ may be congenital or acquired, true or false. Sultan gives the following table of 433 cases:

Congenital herniæ					Acquired herniæ	
True herniæ		Eventrations	False herniæ		True	False
Right	Left	Left	Right	Left		
10	20	8	33	181	10	171

As might be expected, the omentum, stomach, colon are the most common hernial contents, though other organs have been found present.

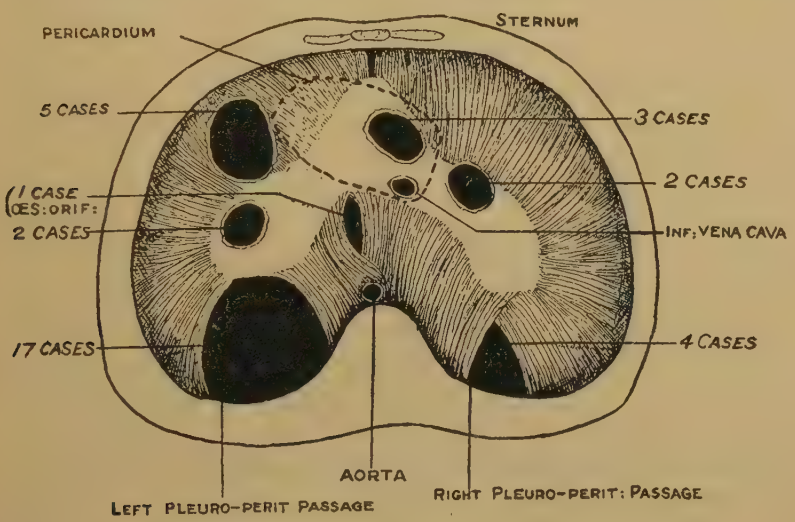

FIG. 45.—Diagram of diaphragm view from upper or thoracic aspect. Sites of diaphragmatic hernia as deduced from 34 museum specimens in London. (*Keith.*)

The symptoms are commonly those of gastric disturbance with pains radiating into the thorax due to temporary strangulation. The heart may be displaced to the right and the left chest be prominent. Increased tympany is a valuable symptom. When the hernia is large, pressure on the lungs and heart may cause much distress.

Examination by means of the X-ray is of much importance. When the hernial aperture is free, a hernia may exist for many years without its presence being discovered. When strangulation occurs its symptoms

are so prominent and the indications for operation are so urgent that the surgeon is rarely justified in wasting precious time with endeavors after a precise diagnosis of causation. Diagnosis has usually been made at the operating or autopsy table. The use of the X-ray has increased the number of diagnoses successfully made before operation.

Treatment.—(1) Prophylactic treatment consists in the careful suture of wounds of the diaphragm and this ought to be done by the transthoracic route.

(2) *Operative Treatment of Diaphragmatic Hernia.*—If the hernia is discovered during a laparatomy for obstruction, the abdomen ought to be protected by warm moist pads and the thorax opened. If the diagnosis has been established before operation, exposure should be made through the thorax, the abdomen being opened later if reduction is found to be difficult. The intrathoracic negative pressure makes reduction through an abdominal wound difficult and the difficulty is much increased by the inaccessibility of the hernial opening from the abdominal side. The dangers from pneumothorax are of course as great when the abdominal route is attempted as when the transthoracic path is utilized.

The Operation.—Unless in emergency when the aid of some differential apparatus or the intratracheal insufflation method is unavailable, one of these valuable means of artificial respiration ought assuredly to be used.

Open the thorax by the reflection of an osteoplastic flap, by the excision of one or more ribs or by a long intercostal incision with forcible retraction of the ribs above and below. For most surgeons resection of the ribs is the easier and hence safer method. Protect the lung, etc., with soft cloths soaked with sterile liquid vaseline. Inspect and treat the hernia *secundum artem.* If there is any difficulty in reducing the hernia, open the abdomen by a convenient incision to get rid of intra-abdominal pressure. Enlarge the hernial aperture if necessary. Reduce the hernia. Close the diaphragmatic opening with sutures. Close the wound in the chest wall but do *not* yet tie the last sutures.

Close the abdominal wound. If differential pressure or intratracheal insufflation apparatus have been used, distend the lungs so as to expel the air in the pleural cavity and then complete the closure of the thoracic wound. If, in the course of some hours or a day or two, fluid collects in the pleura, aspirate it as often may be necessary.

Lumbar Herniæ.—There are two areas in the lumbar region which may be weaker than their surroundings.

1. *Petit's triangle* is bounded by the outer border of the latissimus dorsi, the posterior border of the external oblique and the crest of the ilium. Its floor consists of the internal oblique muscle or its aponeurosis. For a hernia to protrude through the triangle it must penetrate or push in front of it the internal oblique. Dowd (Annals Surg., Feb., 1907) gives an excellent account of this rare hernia. In one case Dowd obtained a cure by approximating the muscles which were separated and by reinforcing the line of suture by pedunculated flaps of fascia.

2. The superior lumbar triangle or rhombus (Grynfeldt; Lesshaft); the lumbar tendinous space (v. Baracz).

v. Baracz found this space in 93.5 per cent. of 76 cadavera examined by him. "The iliocostal muscle forms the posterior boundary of this space and the external oblique, the anterior; the serratus posticus inferior and the end of the twelfth rib are above it; the latissimus dorsi lies over it." The upper portion of the space is the thinnest part of the whole lateral lumbar region and it is penetrated by the twelfth and sometimes the eleventh intercostal nerve and vessels. v. Baracz considers this the commonest site of lumbar hernia (Archiv f. klin. Chir., LXVIII, p. 676).

Lumbar herniæ may be either congenital or acquired.

A. The congenital variety usually appears within the first few weeks of life and being due to absence or imperfect development of the abdominal musculature it may not be confined to the lumbar region but may involve the whole side of the abdomen. It is often accompanied by other developmental defects.

B. Acquired lumbar hernia. Through direct violence or a strain one of the normally weaker areas of the lumbar region may be so opened up that a pouch of peritoneum is pushed into it and forms a hernia. Without any preceding trauma, a strain, as in heavy lifting, may push a pouch of peritoneum into a preëxisting parietal orifice and so give rise to hernia.

Lumbar herniæ of any variety belong to the rarities of surgery.

SECTION III

THE STOMACH

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ANATOMY

Embryology of the Stomach and Small Intestine.—The primitive digestive tube consists of two parts:

1. The foregut, situated in the cephalic flexure.
2. The hindgut, occupying the caudal flexure.

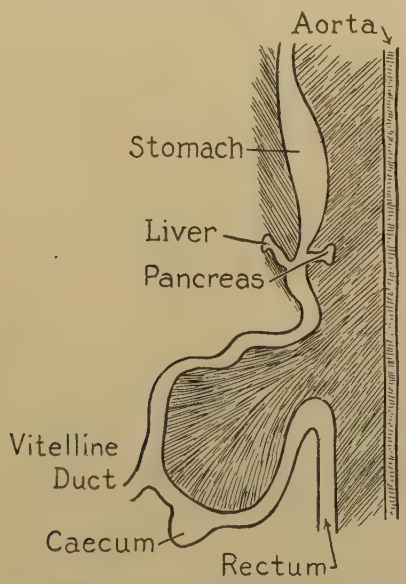

Fig. 46.—Diagram of the alimentary canal seen from the side at an early stage of development.

Between these parts is the communication with the yolk sac. This, later, becomes the vitelline duct and may remain as Meckel's diverticulum, which is present in about 2 per cent. of cases.

The gut undergoes dilatation in parts to form the stomach and cæcum, it gives off diverticula to form the liver and pancreas, and undergoes certain twists before arriving at its complete form (Figs. 46 and 47). (Gray's Anatomy.)

The Stomach.—*Shape and Divisions.*—The stomach is an organ which varies in shape, and presents a very different appearance when in a state of activity from that seen at operations. In the former state it is contracted on its contents; in the latter it is like a flat empty bag.

In the distended condition it is roughly pear-shaped and presents (*a*) two surfaces, an anterior facing into the general peritoneal cavity, and a posterior facing into the lesser sac.

(*b*) Two orifices, the cardiac and the pyloric.

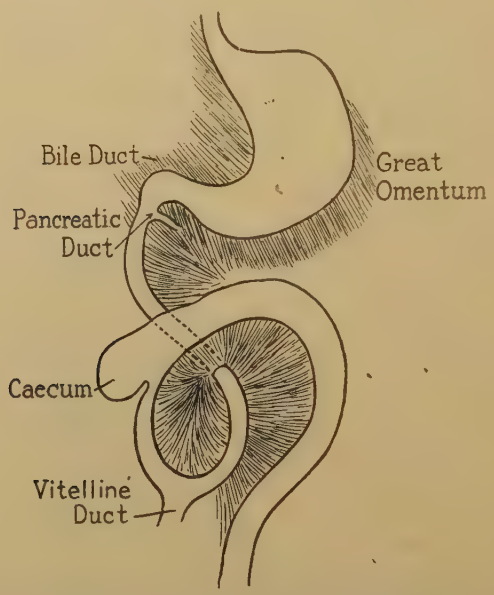

FIG. 47.—Diagram of the alimentary canal as seen from the front at a later stage, showing the elevation of the stomach and the twist taken by the gut.

(*c*) Two borders, known as curvatures; the lesser to which is attached the gastrohepatic omentum, and the greater, to which the gastrocolic and gastrosplenic omenta are attached.

Upon the curvatures are well-marked notches, and lines drawn from these serve to divide the stomach into its various parts (Fig. 48.)

Surface Marking.—Normally the cardiac orifice lies deeply under the seventh left costal cartilage. The pylorus is a hand's breadth below the xiphisternal articulation. The pyloric opening is to be found about ½ in. from the middle line, lower in the upright than in the horizontal posture, in the latter on the transpyloric plane, *i.e.*, the disc between the first and second lumbar vertebræ, and in the former opposite the second lumbar vertebra. The lesser curvature, fixed by the gastrohepatic

omentum, has a fairly constant position, but the movable greater curvature changes its place with the varying condition of the stomach walls or its contents, and the position of the patient, though it seldom, when empty, extends below the umbilicus (Fig. 49).

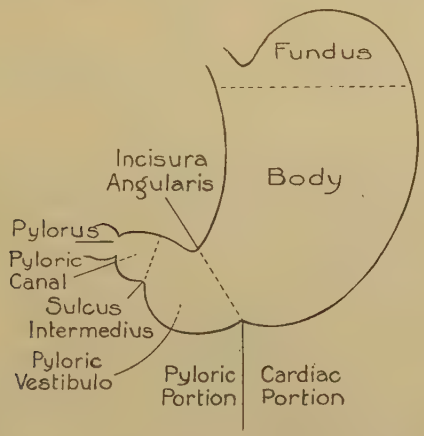

FIG. 48.—Diagram of the stomach showing its shape and divisions.

3. *Blood Supply.*—The blood-vessels of the stomach are derived directly or indirectly from the cœliac axis artery. They run along the curvatures and give off branches to both surfaces. On the lesser curve

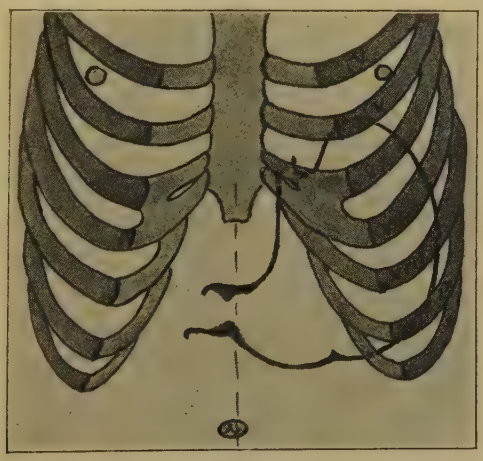

FIG. 49.—Surface marking of stomach.

an anastomosis between the coronary and the pyloric branch of the hepatic, and on the greater curve an anastomosis between the left gastroepiploic branch of the splenic and the right gastroepiploic branch

of the gastroduodenal, takes place. The fundus is supplied by the vasa brevia and branches of the coronary (Fig. 50). A free anastomosis occurs between the vessels of each curvature, but the circulation is least active on a line slightly nearer the lesser than the greater curve, and in the neighborhood of the midgastric constriction.

4. *Lymphatics.*—The lymphatics for the most part follow the vessels. A very free intercommunication with one another exists, so that glands may become infected from any part of the stomach.

FIG. 50.—Skigram of the blood-vessels of the stomach injected with sulphate. The pancreas is also shown. (For names of vessels see Fig. 51.)

Fig. 53 shows the groups of glands. For a detailed account consult the Arris and Gale lectures by Jamieson and Dobson.[1]

5. *Nerves.*—The nerves of the stomach are derived from the two pneumogastrics, and from sympathetic branches from the cœliac plexus which accompany the blood-vessels.

[1] Lancet, Apr. 20 and 27, 1907.

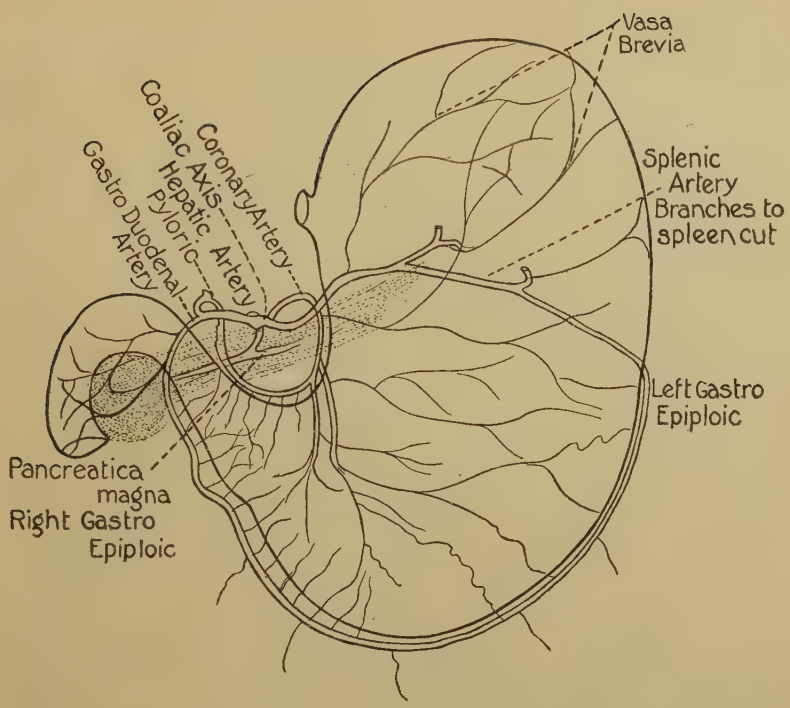

FIG. 51.—Key to skiagram of blood supply of stomach.

FIG. 52.—Skiagram of the anterior wall of the same stomach and duodenum as Fig. 50. Showing the poor blood supply along the middle of the anterior surface of the first part of the duodenum.

Duodenum.—*Anatomy.*—The duodenum is the most fixed part of the small intestine. It is crescentic in shape, the two ends being closely approximated. In the concavity lies the head of the pancreas. It is divided into four parts. The first is in relation with the gall-bladder, the second passes down in front of the right kidney and has opening into itsinner wall the bile and pancreatic ducts, the third part crosses the vertebral column and has in front the superior mesenteric vessels, while the fourth part passes up to the duodeno-jejunal junction.

The pyloric end of the stomach and the first part of the duodenum are of greatest interest to surgeons. Externally the pylorus may appear

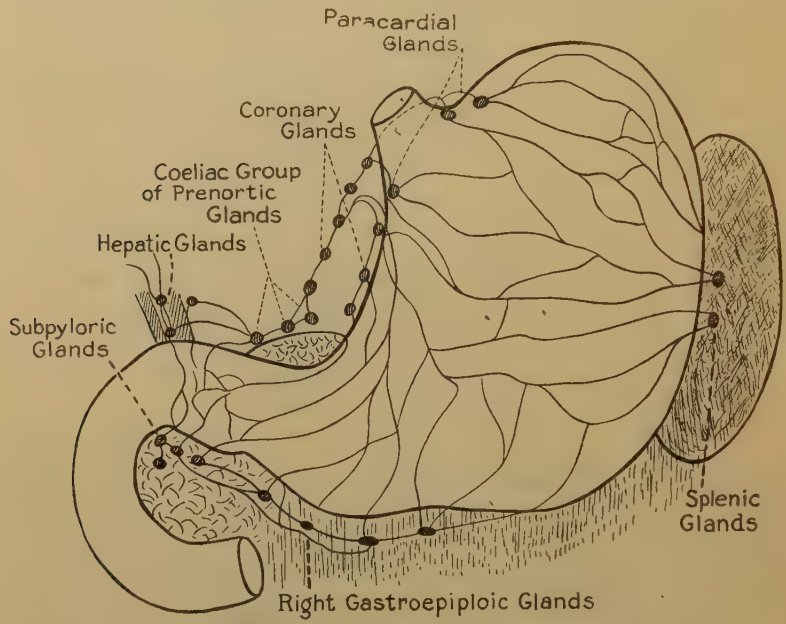

FIG. 53.—Diagram of the lymphatics of the stomach.

as a constriction, and it feels as if an india-rubber ring were embedded in it. If it cannot be recognized in this way, a special venous ring, the lower vessel being the most marked, may settle its site (Mayo). From the cardiac side the pyloric ring should feel elastic and easily admit a forefinger; from the duodenal side it resembles the uterine cervix.[2]

Physiology of the Stomach and Duodenum.—In the stomach, digestion depends upon the chemical action of the secretion and the mechanical mixture of the contents.

The active constituents of the secretion are pepsin and hydrochloric acid.

[2] Cunningham's Anatomy.

Cane sugar is inverted by the acid.

The envelopes of the fat cells are proteolysed and some hydrolysis, of the fat occurs.

Proteins are split up and leave the stomach as albumoses and peptones.

The stomach movements have been studied by means of X-ray and bismuth meals, in animals and man.[1] After food ingestion the stomach is passive for a few minutes and then peristalsis begins. It occurs throughout the stomach, but affects chiefly the pyloric division, the cardiac portion acting as the reservoir.

Four to four and one-half hours after food is taken, the stomach should be empty.

The presence of acid chyme in the duodenum produces a hormone which stimulates the secretion of pancreatic juice. It commences five to twenty minutes after food ingestion and reaches a maximum in three hours. Bile and succus entericus are secreted parallel with this.

The combined juices produce the following effects:
Starches are split into dextrine and maltose, and finally also dextrose. Fats are split into fatty acids and glycerin, the latter being absorbed, the former, also, either in the form of the acid or as soaps. Proteins are split up, beyond albumoses and peptones, into the simpler amino-acids, and are thus absorbed.

The chief movements are due to peristalsis, which consists in contraction above and relaxation below the excited spot. This is known as "the law of the intestine."

Investigation of Cases.—Accurate diagnosis depends upon three things: 1. history of the whole illness, 2. physical signs, 3. laboratory tests, in the above order of importance.

1. *The history*, to which greatest importance is attached, will be dealt with later in connection with a description of the particular diseases.

2. *Physical Signs.*—For the discovery of physical signs the patient should lie easily, on the back, with shoulders raised, knees slightly bent, breathing quietly with open mouth, and the abdomen should be wholly uncovered.

Warm examining hands and gentle use of them, in a hot room, are important aids.

Inspection.—A general view of the patient may convey a most use-

[1] Cannon (Starling's Physiology).

ful hint, *e.g.*, the anæmia of a bleeding duodenal ulcer is entirely different from the cachectic anæmia of cancer. Locally, an epigastric tumor, peristaltic contractions and distention of the stomach, are the most important evidences of something wrong.

Palpation.—Localized rigidity, or tenderness, or both, with their situation and extent, may be useful guides. The presence of a tumor, its consistency, the characters of its surface, of its edge, and its relations often offer sufficient evidence upon which to base a diagnosis. Gastric tumors, unless fixed, move with respiration, and pulsation may be transmitted to them from the aorta. Peritoneal friction, if felt, indicates localized peritonitis, and continued succussion, dilatation or atony of the stomach.

Percussion.—More accurate methods of measuring the size of the stomach have now replaced percussion and auscultatory percussion, but percussion may still be of great value in determining the presence of free fluid in the abdomen after rupture of the stomach, and in discovering alterations in the liver dulness in these cases.

The size of the stomach can be best ascertained, after the passage of a stomach tube, by measurement of the quantity of fluid it will hold, or by distention with air through the tube by a bicycle pump, and inspection of the abdomen. In either case care should be taken lest harm be done.

Actual seeing into the stomach, by use of the gastroscope, is likely to be *the* method of diagnosis of the near future, as with similar instruments in other hidden recesses of the body, but as yet knowledge is not sufficiently advanced to offer it as a practical suggestion. The gastroscope of Rovsing which is introduced through an opening in the anterior wall of the stomach has proved of diagnostic value in the course of certain operations.

In the meantime skiagraphy is our best aid. Foreign bodies, such as coins, tooth-plates, etc., can be safely and readily discovered and located.

By feeding with bismuth or barium sulphate and examining with a screen, the passage of food from the mouth through the whole of the alimentary tract has been observed. Changes in shape (hourglass) alterations in the motility (diminution or excess), the presence of tumors or ulcers, and obstructions by stricture, kinks, etc., have all been diagnosticated by these aids.

3. *Examination of Vomited Matter.*—Note the general characteristics of this.

1. Color (brown, red, green, coffee ground, etc.).

2. Odor (sour, yeasty, foul, fæcal, etc.).

3. Quantity (actual amount and whether in excess of what has been taken).

4. Froth.

More minute examination may show:

Mucus.—When this is intimately mixed with food it comes from the stomach-wall, as in chronic gastritis. Unmixed with food and presenting a glairy ropy appearance it commonly comes from the œsophagus. Mucus from the air passages is usually nummular and purulent.

Particles of undigested food, partaken of a long time previously, at once suggest pyloric obstruction and dilated stomach.

Blood may be found in either macro- or microscopic quantities. It soon undergoes changes in the stomach, but when recent is either bright red, or, if time has been allowed to convert the hemoglobin into hematin, of a coffee-ground appearance.

Bile is an uncommon content of the stomach in surgical cases. Its presence suggests that the pylorus is free from obstruction.

Pus.—The most common origin of this is the respiratory passages, but it can be present when the stomach is inflamed or ulcerated.

Fæces are rarely met with. The presence of solid fæcal matter indicates a gastrocolic fistula.

Microscopic examination may discover portions of tumor, or blood, or show varieties of microörganisms, torulæ, sarcinæ ventriculi, etc.

Stomach Tube and Test Meals.—A stomach tube passed in the morning before breakfast should find no remains of a meal of rice and currants, taken the night before. Any residue indicates impairment of motility. A meal of meat and vegetables, taken after washing out, should have entirely left the stomach in six hours. Salol taken by the mouth is split by the pancreatic juice into salicylic and carbolic acids, which appear in the urine and can be discovered by the ferric chloride test. The time of its appearance is a rough guide to the motility of the stomach.

Estimation of the Gastric Secretion.—The stomach is first washed out, and a test meal, consisting of a slice of dry toast or bread and ½ to 1 pt. of tea without sugar or cream, is given. After an hour the stomach contents are removed and analyzed.

Stockton[1] offers useful hints and diagnostic indications. The

[1] Journal American Medical Association, Dec. 11, 1909.

stomach tube should be of good size and about 54 in. long. The tube, taken out of warm water and lubricated with glycerine, is passed while the patient tries to swallow.

Finding portions of the test meal returned unmixed with gastric juice about 14 in. down, is evidence of obstruction at the cardiac orifice. The average distance at which the best re-flow occurs is about 22 in. from the teeth.

A large quantity of matter undergoing fermentation with a musty odor, a large number of sarcinæ and bacilli, a full secretion of HCl, and few lactic acid bacilli indicate a pyloric obstruction of non-malignant character.

Stagnating food of foul odor, with or without free HCl, with lactic acid and the Oppler-Boas bacilli, and unchanged or occult blood present, suggests malignancy and obstruction.

In drawing off the stomach contents note how they discharge. A forceful ejection suggests muscular hypertrophy. In extreme atony, no contraction may take place and escape of the material is wholly dependent on siphonage.

Chemical Investigation of the Stomach Contents.—Free hydrochloric acid is present in the normal stomach contents after a test meal, the average amount being 0.02 per cent.

It is increased in gastric ulcers near the pylorus, except in the later stages, but more so in duodenal ulcers. Free hydrochloric acid is almost always absent in cases of cancer, and the acid combined with proteins is also diminished. In cases of chronic gastritis the acid is also diminished, but that combined with proteins not so much as in cases of cancer.

In connection with the quantitative estimation of the hydrochloric acid, the "active" acid is that investigated, including that which is free and that combined with proteins or organic bases. Robert Hutchison[1] recommends this as the best test.

Eosinophilia.—A large number of eosinophiles in a cover-glass preparation of the stomach contents has been believed to suggest cancer, though Norcanin[3] has found eosinophilia in a case of achylia gastrica.

Permanent disappearance of blood from the fæces is the surest sign of cure of an ulcer.

For the various chemical tests, the student is referred to some special work on the subject.

[1] Med. Annual, 1911, 326.
[2] Wien. Klin. Woch., 1911, 1335.

Injuries and Foreign Bodies.—*Corrosives, Etc.*—Injuries of the stomach and duodenum may result either from without—*violence*—or from within—*foreign bodies, corrosives, etc.* 1. Blows and crushes of the upper abdomen may result in partial or complete rupture of the stomach or duodenum.

A partial rupture is generally, so far as is known, limited to the mucous membrane, causing hematemesis or melæna. It may terminate in a "traumatic ulcer," having the same symptoms and signs, the same complications and terminations, offering the same prognosis, and requiring the same treatment as the more ordinary forms of gastric ulcer.

Because of the absence of typical symptoms and signs it is probable that partial ruptures of the outer coats, not involving the mucous membrane, are usually overlooked, being discovered only during operations undertaken for some other cause, and that they are seldom of practical importance.

Complete rupture usually occurs when the stomach is full, results in a wide extravasation of its contents, and is accompanied by the immediate development of shock which is severe because of the injury and the extravasation of stomach contents. Rupture is soon followed by signs of free fluid and gas in the abdomen, and later by those of peritonitis. Local tenderness and rigidity of the overlying muscles are the earliest and most important signs of this, as of most abdominal catastrophes. The treatment is operation at the earliest possible time and, during operation, endeavors should be made to counteract the shock present, by external application of heat and by intravenous infusion of normal salt solution (ʒi of chloride of sodium to 1 pt. of water) to the extent of 2 pt. slowly introduced at a temperature of 100°F. The guiding principle of the operation is to close the gastric tear as gently and as soon as possible, and to remove the extravasated stomach contents.

Available statistics show that 18 per cent. of cases of ruptures of the intestine occur in the duodenum and that the majority of these involve the second part. The tear may be either intraperitoneal when conditions similar to those following rupture of a duodenal ulcer result, or extraperitoneal, when, although the immediate effects may be less serious, the remote results (cellulitis, abscess, fistula, etc.), may be no less deadly, and are more difficult to deal with on ordinary surgical lines.

Stab and gunshot wounds are less frequent in this country than in America, but surgeons everywhere recognize that operative treatment

(closure of the wound and removal of extravasated contents) is the only reasonable course to take, and this is followed by yearly increasing success. In performing these operations it is essential to bear in mind that a large number of failures has arisen from overlooking other injuries, more difficult of detection, *e.g.*, associated wounds of liver, spleen, kidney, diaphragm, etc., and that, in the case of the stomach, the operation has not been properly completed till its posterior wall and the pancreas have been examined, preferably through an opening made either in the gastrocolic omentum or in the transverse mesocolon. It is also important to remember, in the case of gunshot wounds, that the object of the operation can be attained without immediate removal of the bullet, and that no serious addition to the operation, to satisfy a natural desire to recover it, is justifiable.

Gastric and Duodenal Fistulæ.—These, though not exclusively the result of injury, may be dealt with now.

A fistula may be described as a tubular ulcer, with an internal opening into a hollow viscus and an external opening, either on to the surface or into another hollow organ.

Gastric fistula may be the direct result of injury (the celebrated case of Alexis St. Martin), of operation (gastrostomy), of the perforation of an ulcer, simple or malignant, either on to the surface or into an adjoining viscus, of the destruction resulting from a perigastric abscess, or of the escape of a foreign body.

An established fistula may not be a menace to health or long life, and may heal spontaneously, if no obstruction exists against the normal escape of the stomach contents. The danger varies chiefly according to the cause and position of the fistula. The external opening of the fistula is usually in the epigastrium, but it may track through between the ribs or elsewhere. The internal opening may be in the cardiac or pyloric portion. In two cases under my observation a cancerous ulcer had established a fistulous communication between the stomach and the transverse colon. All food taken into the stomach passed almost immediately into the colon, as seen by X-rays after a bismuth meal, and an enema of turpentine was vomited a few minutes after its administration. In the ordinary case with external opening, gastric juice is continuously discharged, the skin around is sore and excoriated, food escapes, and the patient emaciates more or less rapidly from starvation. If the internal opening is in the cardiac end of the stomach the prognosis is good, food-escape occurs only intermittently and in small quantity, and, with some aid and careful dressing, spon-

taneous closure can occur. If, on the other hand, the internal opening of the fistula involves the pyloric end, the discharge of gastric juice and food is continuous and in greater amount, emaciation is rapid, spontaneous healing rarely occurs, and, without an operation for the closure of the fistula, death is the almost inevitable result. The needful operation consists in separation and closure of the internal fistulous opening, other complications being dealt with on ordinary surgical lines.

Duodenal Fistulæ.—These may be the result of abdominal injury or operation, perforation of an ulcer from within, or perforation of gall-stones or an abscess from without. The discharge from a fistula, which opens externally, has bile and pancreatic juice in it, in addition to chyme from the stomach. The skin erosion and the emaciation are more marked than in gastric fistulæ, the prognosis is consequently more grave, and the operation which is likely to be necessary for its closure is certain to be difficult and, therefore, serious. Where discharge is considerable and continuous, the case is urgent and valuable time should not be lost in useless tinkering; but, when the discharge is small in quantity and intermittent, there is a chance of spontaneous healing and it should be given. In the most serious cases it is seldom possible to secure satisfactory closure and healing of the duodenal opening on account of skin sepsis, the difficulty of isolating the duodenum, and the fragility of its wall. The best method is to avoid direct attack on the fistula and to perform gastroenterostomy, followed by closure of the pylorus.

Injury Due to Swallowing Corrosive Fluids.—Either strong acids or alkalis, swallowed by accident or with suicidal intent, produce their worst results in the pyloric end of the stomach. If the corrosive is strong enough, all tissues with which it comes into direct contact are destroyed, and perforation of the stomach with subsequent peritonitis results, *i.e.*, if the patient live, long enough. The more ordinary result is that acute inflammation of the stomach is produced and, if the patient recover, the ordinary terminations of inflammation everywhere, viz., resolution, fibrosis, partial destruction, and total destruction, result.

Fibrosis may be either local or diffuse, so that a stricture at either orifice, and hour-glass deformity, or diffuse thickening and contraction of the stomach-wall may be found.

Partial destruction produces sloughing and ulceration, and this may become chronic and cause hemorrhage or perforation, or cicatricial contraction with deformity.

Total destruction. Gangrene of the stomach-wall is seldom complete before the patient dies.

Foreign Bodies.—All sorts of foreign bodies have been found in and removed from the stomach. The most interesting of these is the hair ball (Fig. 54). In human beings it is almost limited to girls and in them, if a large tumor free from tenderness is found in the epigastrium, it should be suspected. Corroboration may be obtainable from a history of hair biting, or of vomited matter or fæces containing hair.

Fig. 54.—Hairball removed from the stomach of a female child, age 9, the daughter of a shepherd, by my colleague, Mr. A. Martin, Royal Victoria Infirmary, Newcastle-upon-Tyne. 1, Cardiac end; 2, pyloric end.

INFECTIONS OF THE STOMACH INCLUDING TUBERCULOSIS AND SYPHILIS

Acute Gastritis.—"*Phlegmonous Gastritis.*"—Inflammation of the stomach in its etiology, pathology, symptoms, prognosis and treatment resembles all septic inflammations.

Etiology.—It is due to organismal infection involving especially the submucous coat. The usual organism is a streptococcus, but staphylococci, bacillus coli, and pneumococci have also been found.

It may arise without demonstrable cause (primary or idiopathic) or result secondarily from a local or general condition. Of the local conditions, benign or malignant ulcers and traumatism are the chief; of general conditions, septicæmia (wound or puerperal) and the exanthemata (typhoid fever or small pox) have been recorded.

Pathology.—The inflammation may be diffuse, when the stomach-wall is reddened, thick, boggy from œdema, and infiltrated with a purulent exudate, as in cellulitis, or it may be circumscribed and form a suppurating tumor, *i.e.*, an abscess.

The disease occurs at any age and affects males chiefly.

Symptoms.—In the diffuse variety the onset is so sudden and painful that a diagnosis of ruptured ulcer may be made, though frequent vomiting is usually a distinguishing and urgent symptom. The vomited matter may contain pus or portions of foul necrotic stomach-wall, inflammatory fever is marked, the temperature usually reaching 102° to 103°F., the pulse is quick, and the appearance that of a profound toxæmia, with collapse and possibly delirium.

In the circumscribed form the symptoms are less pronounced and milder, and it is frequently possible to discover a tender tumor.

Prognosis.—In the diffuse form death usually occurs within a week, either from septicæmia or from peritonitis.

In the circumscribed variety an abscess can burst into the stomach with recovery, or into the peritoneum, usually causing death from peritonitis.

Treatment.—The only treatment likely to have any chance of success in the diffuse variety is to give the stomach rest and to relieve the tension on its walls. Mayo Robson[1] has suggested gastroenterostomy and carried it out successfully in the localized form, and this is probably the best treatment for this variety. If an abscess is found it must, of course, be opened.

For the diffuse form my view is that the abdomen should be opened through a long incision, that jejunostomy should be performed leaving the jejunum attached at the lower end of the wound, that the stomach-wall should be freely incised in several places down to, but not through, the mucosa, and that the upper part of the wound should be sutured, but left open, and packed round and over the stomach with sterile gauze, kept in position by tying the sutures in slack bow knots. These can be tightened up later, when the gauze packing is removed.

Cirrhosis of the Stomach (*Linitis Plastica, Fibromatosis*).—Certain scars in the skin develop in connection with them a tumor-like growth of fibrous tissue, to which the name of keloid has been given. These growths are well known and have a special relation to prolonged sepsis (burns) and tubercle (tuberculous scars). In the gastrointestinal tract similar tumors are found related to sepsis and tubercle. They occur

[1] Keen's Surgery, p. 265.

especially in connection with septic changes in sacculi of the colon ("diverticulitis") generally on the left side. A similar tumor, often related to tubercle, occurs on the right side (hyperplastic ileocæcal tuberculosis). It seems probable that the changes occurring in the stomach, most satisfactorily described as fibromatosis, own a similar pathology, because chronic ulcer, tubercle, and syphilis have all been described as causes. The relationship of the condition to cancer and the difficulty of distinguishing the benign from the malignant variety are emphasized elsewhere (p. 114).

Tuberculosis of the Stomach.—This is a rare condition and is probably never primary. The miliary form, affecting the peritoneum as part of a diffuse infection, is of no surgical importance. The surgeon sees that tubercle appears in the stomach, as elsewhere in the body, in the form of either a tumor or an ulcer.

The tuberculous tumor is chiefly composed of fibrous tissue, with few giant cell systems, little or no caseation, and tubercle bacilli often indiscoverable even after prolonged and careful searching. It occurs most commonly at the pyloric end of the stomach, causes symptoms and signs of obstruction, and at operation is likely to be mistaken for cancer. In both tubercle and cancer microscopic examination of excised glands may give information as to the nature of a tumor, otherwise unobtainable.

Tuberculous ulcers may be multiple or single. They give rise to the same symptoms and signs, and are followed by the same complications[1] as simple ulcer, from which it may be difficult to distinguish them without microscopic examination.

Treatment.—Excision followed by gastroenterostomy or gastroenterostomy alone is usually followed by good results.

Syphilis of the Stomach.—This occurs as a tertiary lesion and, though rare, is probably, on account of the difficulties in its recognition, not so uncommon as is usually supposed. Like tubercle, it appears either as a tumor or an ulcer, according to the chronicity or otherwise of its course, the tumor being a fibrosing gumma, the ulcer one that has broken down.

The symptoms and signs produced are those of ulcer or cancer, and the importance of its recognition depends upon the fact that rapid recovery follows the use of antisyphilitic remedies. It is consequently wise never to ignore, in a stomach case, other syphilitic

[1] Osler, Principles and Practice of Medicine.

manifestations, and, if any doubt is felt as to the presence of syphilis, to employ the Wassermann test before suggesting operation.

Ulcers.—*Acute and Chronic.*—*Etiology.*—There are many explanations but there is no agreement as to the cause of gastric and duodenal ulcers.

Sex.—Females are said to be more predisposed than males, in the proportion of 3 to 2, though some doubt has been thrown on this by Mayo's figures.

Acute, perforating, gastric ulcers are almost limited to young women, and acute, perforating, duodenal ulcers to men over 35 years of age.

Of chronic ulcers, those in the body of the stomach are probably more common in females. Chronic duodenal ulcers occur almost exclusively in males.

Age.—No age is exempt, as ulcers have been found in a baby three days old and in a patriarch of 96, though the majority of acute perforating ulcers are found between 18 and 30, and chronic ulcers after the thirtieth year. In females about 75 per cent. of ulcers occur before the age of 30, and in males the same percentage after that age.

Occupation.—No specific occupation is known to predispose to ulcer, but the disease is considerably more common among the neglected poor.

Heredity.—It is so rare to obtain a history of similar family trouble that it is fair to say that heredity has but a trifling influence, if any.

Nervous Influences.—The resemblance, in appearance, of chronic gastric ulcer to trophic perforating ulcer of the extremities, and the local anæmia produced experimentally by damage to the vagus nerve, have suggested nerve influences, but there is no clinical support in evidence of these views.

Traumatism.—The effect of injury to the stomach-wall has been previously mentioned, and rare cases have been observed, in which injury has been followed so directly by an ulcer as to imply clearly cause and effect.

Corrosive poisons, if their immediate effects are recovered from, may more remotely cause ulceration.

Surface Burns.—A sufficient number of duodenal ulcers, following burns and scalds, has been recorded to show a definite connection. On two occasions I have seen death caused by perforation of a duodenal ulcer consequent on septic skin burns. These ulcers appear about the tenth day after the injury.

Embolism has been for long a favorite explanation, and, though some support has been given to it by the careful experiments of Wilkie,[1] showing how easily a reversed venous current may be brought about in the omental circulation, and retrograde venous emboli be produced, there is no good evidence that it is a usual cause of ulcer.

Appendicitis.—Moynihan[2] expresses the view that a chronic and persistent infective lesion, with acute exacerbations, is the primary cause, its most common site being the appendix. The stomach and duodenal lesions are secondary, and due to retrograde emboli as mentioned in connection with Wilkie's experiments. Though it is true that old inflammatory changes in the appendix are frequently found in gastric and duodenal ulcer cases, it does not follow that they are cause and effect.

Intestinal Stasis.—Lane teaches that gastric and duodenal ulcers are the direct result of intestinal stasis produced by his "ileal kink." Stasis leads to a reversed current of bacteria-laden fluid, and infection and ulceration of the duodenum, bile and pancreatic ducts, and stomach follows. This view carries with it the conviction that gastroenterosotomy, unless obstruction is present, is a useless operation, and that either ileosigmoidostomy or colectomy is the proper treatment. Further evidence is required before this position can be accepted.

Hyperchlorhydria.—Though hyperchlorhydria can be present without ulceration, Osler[3] quotes statistics from Riegel's clinic showing that 19 of 21 chlorotics had hyperchlorhydria; the important part played by the acid secretion of the stomach, in producing or maintaining ulceration, is generally accepted. The fact that ulceration is almost limited to the first part of the duodenum, *i.e.*, the portion where its contents are acid, emphasizes the importance of this.

Autolysis.—Bolton's experiments[4] are of the greatest possible interest in connection with gastric ulceration. He obtained a specific cytotoxin by injecting an emulsion of the living cells of the gastric mucous membrane of a guinea-pig into a rabbit. Some of the rabbit's serum, injected into a healthy guinea-pig, caused destruction and ulceration of the gastric mucous membrane, and, at the same time, some hemolysis was produced. If soda was introduced into the stomach in sufficient quantity to neutralize the acid gastric juice, ulceration did not occur, while an increase of hydrochloric acid made the

[1] Edinburgh Medical Journal, May, 1911, Vol. VI, p. 391.
[2] Brit. Med. Journal, Feb. 17, 1912.
[3] Principles and Practice of Medicine.
[4] Proc. Roy. Soc. B. V., 82, 1910.

occurrence of ulceration more certain. He also found that motor insufficiency caused delay in healing, and that an acute ulcer could be thus converted into a chronic one. His ingenious suggestion is that a cytotoxin, similar to the one he obtained experimentally, may be produced by auto-intoxication, and that the resulting gastrolysin and hemolysin may cause ulceration or the obscure hematemesis which has no known cause.

Other causes which have been suggested may be mentioned but require no detailed consideration. They are:

1. Embolism (*i.e.*, not retrograde venous).
2. Endarteritis or thrombosis.
3. Vascular spasm.
4. Direct pressure on vessels.
5. Hemorrhage into the stomach-wall apart from traumatism.
6. Disease of the solitary glands.

General surgical principles have been too little considered in this connection, and it is safe to say of chronic ulcers, that they are in the great majority of cases the result of trauma plus septic inflammation. The initial trauma may be an abrasion caused by mechanical, thermal or chemical means, the septic organisms being conveyed by the pharynx and œsophagus in the act of swallowing. Injury would be most likely to occur (1) where the passive cardiac reservoir joins the active pyloric canal in the neighborhood of the midgastric sphincter; (2) in the neighborhood of the pylorus; (3) in the pyloric mill; and (4) in the cardiac end in this order of frequency. Of 66 chronic ulcers of the stomach operated upon in the Royal Victoria Infirmary, Newcastle-on-Tyne, in 1910, 35, *i.e.*, 53 per cent., were found at the cardiac and pyloric junction and 31 or 47 per cent., in the neighborhood of the pylorus and in the pyloric mill, and the same figures nearly serve for the subsequent years 1911 and 1912. The statistics of Fenwick and Welsh[1] based upon 1808 cases, accord closely with these. Ulcer in their cases occurred in the cardiac end only in about 7 per cent. of instances.

In the majority of cases I believe the source of the sepsis to be carious teeth and pyorrhœa alveolaris, and that the resulting septic gastritis is only part of a general septic gastroenteritis, leading to those changes in the appendix, ileum and elsewhere, which Moynihan and Lane regard as primary causes of the mischief. The infective character of the ulcers in the stomach and duodenum is emphasized by the

[1] Ulcer of the Stomach and Duodenum.

frequency with which they are found on opposing surfaces (Figs. 57 and 58).

It is very rare to find ulcers in the duodenum beyond the bile papilla. Those on the anterior and outer part of the first portion are

FIG. 55.—Diagrammatic representation of the areas affected in the great majority of cases of perforating gastric and duodenal ulcer.

prone to perforate, while those on the inner and posterior wall, lying in close apposition to the gastroduodenal artery and the pancreas, are most likely to bleed.

FIG. 56.—Acute perforating ulcer of the anterior wall of the stomach, viewed from within. Note the typical "shelving" edge and small round perforation.

In both stomach and duodenum, the pathology of acute ulceration and perforation, I believe, is different from the above in many cases. In these a circular patch of gangrene is rapidly developed in an area where the blood-supply is most defective and perforation follows separa-

FIG. 57.—Posterior wall of the previous specimen, viewed from within. The arrow points to an acute ulcer, arising from direct contact with the acute perforating ulcer of Fig. 56 and due to direct infection.

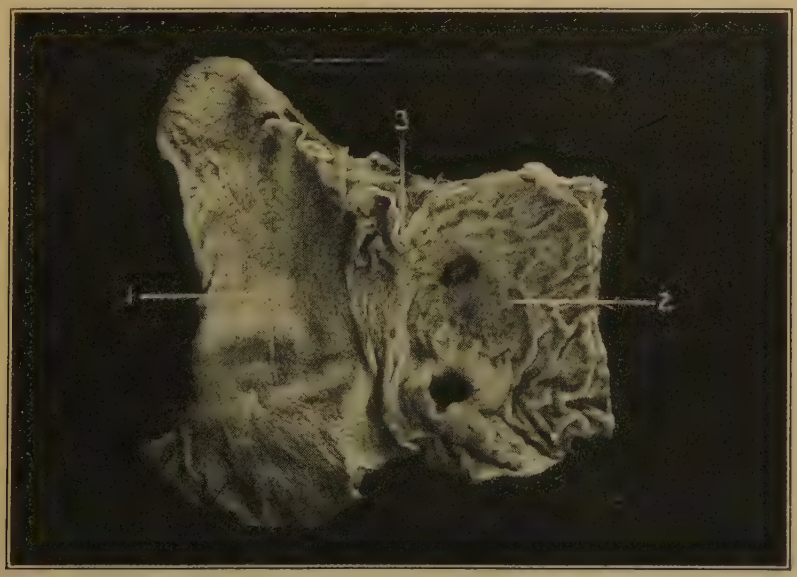

FIG. 58.—Perforating ulcers of the duodenum—the upper resulting from contact with the lower, which is the older. The shelving edge is well seen in the upper. 1, Stomach; 2, duodenum; 3, pylorus. Posterior surface of specimen has been incised and the gut spread out.

tion of the patch (Lancet, 1906, Vol. I, p. 961, on "tension gangrene of the hollow viscera," and An Introduction to Surgery, p. 116. Rutherford Morison). This gangrene is caused by interference with the blood-supply, owing to distention of the stomach by an acute attack of retained flatus. Perforation, in the case of the stomach, occurs in 70 per cent. of our cases on the anterior wall, in a small area about midway between the two curves and between the cardiac and pyloric orifices, but a little nearer the lesser than the greater curve and somewhat closer to the cardiac orifice than the pyloric. In the duodenum it is almost invariably found at the upper, anterior and outer portion of the first part, where the vascular supply is most defective (Figs. 50, 51, 52 and 53).

Acute Gastric and Duodenal Ulcers.—Except for their complications, perforation and hemorrhage, acute ulcers do not belong to the surgeon, but come within the sphere of the physician. Their diagnosis is chiefly a matter of conjecture, and statistics, except when verified by operation or post-mortem, have been proved by recent surgical work to be wholly unreliable. It is at least safe to say that the medical diagnosis of gastric ulcer in a young woman, in the very great majority of cases, is wrong, and that perforation is often the first definite evidence of an ulcer in them. The favorite subject of acute perforating ulcer is the stout chlorotic young woman; of acute perforating duodenal ulcer, a robust man between 35 and 40 years of age.

The usual classification of acute ulcers is into:

1. *Erosions*, superficial, often multiple abrasions, affecting the mucous membrane only, and perhaps difficult of demonstration even with a lens. Their importance is due to the fact that serious hemorrhages may result from them.

2. *Acute Round Ulcer.*—This is commonly about ½ in. in diameter, has a punched-out appearance, a shelving edge, a base without granulations and smaller than the surface (seen microscopically to be composed of necrotic tissue) and little or no surrounding infiltration (Figs. 56 and 58).

It is, as previously mentioned, chiefly found on the anterior wall of the stomach somewhat nearer the lesser than the greater curve, and, from its tendency to spread through the peritoneal coat, is often spoken of as the "acute perforating ulcer."

Symptoms.—Whether an ulcer is acute or chronic, the symptoms which suggest a diagnosis are the same three, viz., pain, vomiting and discharge of blood. In the acute variety their interrelationship is not

so close and sequential as in the chronic form. Pain, such as I shall describe later as typical of gastric ulcer, is often absent, vomiting is rare, and hemorrhage, which is not uncommonly the only evidence, takes precedence of the other symptoms. The blood may be vomited, causing a hematemesis, profuse, painless, and perplexing, or it may be passed through the bowel, or both melæna and hematemesis may be present. The important point to remember, in connection with the hemorrhage of acute ulceration, is that, though so terrifying, it is rarely fatal, that it usually undergoes spontaneous cessation, and that, though the patient may be reduced to a condition of the most profound anæmia, she seldom fails to recover.

Chronic Gastric and Duodenal Ulcers.—Three symptoms are common to chronic gastric and duodenal ulcers; pain, vomiting, and discharge of blood. All of these may be present and yet the patient not have either a gastric or a duodenal ulcer, and this is especially true in the case of young women. A detailed consideration of these symptoms is, therefore, of importance.

Pain.—This is the most important, may indeed be the only symptom of a gastric or duodenal ulcer. To take this place of priority it must have quite a definite history. Unless it occurs after the ingestion of food, and is absent when the stomach is empty, no serious diagnostic importance attaches to it. My practical rule, based on these considerations, is that a pain occurring after 4 A.M., that is, before breakfast, is not likely to be associated with either chronic gastric or duodenal ulcer. In cases of old standing, large, indurated ulcers, when the period of chronic invalidism has been reached, this rule may not apply, and though the present complaint may be of pain only, it is of a pain so persistent as to make life a misery, a pain which neither rest nor diet removes and which opiates can only alleviate. In these cases, moreover, there is usually a previous history of vomiting and hematemesis, and frequently the after-recovery from a perforation.

If there is an ulcer and the pain is continuous, such pain is more likely to be due to cancer than to a simple ulcer. In cancer the pain is attended by loss of appetite, but in ulcer the patient would willingly eat if he dare. If the pain is not relieved at once by vomiting the contents of the stomach, it is not likely to be due either to a gastric or duodenal ulcer, unless this be cancerous.

The time at which the pain appears has some value in localization, but not all that has been claimed for it. Beginning soon after a meal, about half an hour, it suggests an ulcer toward the cardiac end

of the lesser curve; one to one and one-half hours after food, an ulcer at or near the pylorus; and from two to three hours after, an ulcer in the duodenum.

The relation of the ingestion of different foods to the relief or aggravation of the pain in the various ulcers is interesting. In ulcers of the lesser curve, toward the cardiac end, ingestion does not relieve the pain, and a heavy meal, *i.e.*, one composed of meat and such-like, brings on the pain earlier and causes it to be more severe than when a light meal, *e.g.*, milk, is taken. In ulcer in the region of the pylorus one usually obtains a history of relief to the pain on taking food, the relief lasting one to one and one-half hours. Lastly, in duodenal ulcers, relief is again obtained by taking food, this time for a longer period, usually two to three hours, and heavy food delays the onset of pain longer than light, but the pain is more severe when it does begin. Dieting does not produce so beneficial an effect in duodenal as in gastric ulcers, the latter being quite often relieved by soft, careful feeding.

The cause of this pain has been much discussed, but the explanation of it has not yet been fully revealed.

The most popular belief has been that it is the result of food contact, but this view is opposed by the facts that, in ulcer of the cardiac end of the stomach, pain usually does not commence for half an hour after food, and in duodenal ulcer pain does not commence till two or four hours after a meal, whereas food reaches the cardiac-end ulcer at once, and the duodenal ulcer in a few minutes.

Another widely accepted opinion, that the presence of hydrochloric acid was the cause of the pain, was upset by Herz[1] who proved by experimental administration of acid in stomach ulcer cases that it is incorrect.

Mansell Moullin believes that the pain is due to spasm of the involuntary muscle of the stomach-wall, and it seems likely that food contact, plus HCl, are the necessary stimuli to this reflex muscular contraction, and that the pain then obeys the rule, that all "surgical" pain is due to tension.

The immediate relief given by gastroenterostomy to patients, whose pain has been the most urgent symptom, is best explained by the relief of tension following it.

Considerable attention has been paid to the symptom described as "hunger pain," thought to be characteristic of the presence of a duodenal ulcer, but, like the majority of other "pathognomonic

[1] Goulstonian Lecture, Royal College of Physicians, March, 1911.

symptoms," it has failed to fulfil expectations, and is now known to be associated with chronic ulcer of the stomach as well.

It is characteristic of the pain of both chronic gastric and duodenal ulcer that it has periods of attack and intervals of remission. In the early stages of both, the attacks are likely to be of short duration while the remissions are long. Later, the attacks become longer and the remissions shorter. In both, "attacks of indigestion" and "blowing out with wind" are most common in the cold weather (Moynihan), or in periods of stress and anxiety.

Pain and tenderness in gastric ulcer are usually felt in the epigastrium and to the left of the midline; in duodenal ulcer, to the right, behind the upper part of the rectus muscle. In both, it may radiate to the back between the shoulder blades.

The chief pain in the early stages of duodenal ulcer is felt about four or five in the afternoon, three to four hours after the midday meal; later, it occurs after every meal.

Night pain, occurring about 1 to 2 A.M., is more common in duodenal than in gastric ulcers. In both, I have made the diagnosis that the ulcer was adherent to the pancreas, and almost invariably have found it to be so, though I can offer no explanation. Patients with this pain usually give a history that they had been in the habit of taking hot milk, hot water, biscuits, or soda mint to the bedroom with them, in order to get relief and sleep, from taking one or other when the pain came on.

A patient with duodenal ulcer usually endeavors to relieve himself by lying curled up or sitting up, bent forward, though, occasionally, the greatest relief is obtained by lying on the back with hyperextended trunk, or in the prone position with the belly pressed on a pillow.

Paroxysmal pain, *closely resembling that of biliary colic*, is associated with an ulcer close to or involving the pylorus, either on its gastric or duodenal side.

Vomiting is a most important symptom in chronic gastric, and of little importance in duodenal ulcer. To take this important place it must, like the pain, have a quite definite history, or its presence may be entirely misleading. It should bear a definite relationship to the pain and ingestion of food. Vomiting, without severe pain, or occurring at other than fixed periods after food, is not a symptom of any value in the diagnosis of chronic gastric ulcer.

The vomited matter is most likely to be nothing but ingested food, and after the stomach has been emptied by the act of vomiting the

patient should feel entire relief at once. Both sickness and pain are comparatively easily relieved by limiting the quality and quantity of food, and by rest. Vomiting, which is not controlled by rest in bed and by fluid diet, is quite unlikely to be due to gastric ulcer. Vomiting is rare in cases of uncomplicated duodenal ulcer. When it occurs, patients will often tell how, having discovered that relief followed emptying of the stomach, they had purposely induced vomiting in order to remove a severe pain. It is generally true to say that vomiting in gastric ulcer is usual and involuntary, and in duodenal ulcer uncommon and voluntary. The quantity and quality of the vomited matter may be most important evidence of complication of gastric and duodenal ulcer, to be dealt with later.

Blood.—The presence of blood occurs in not less than 75 per cent. of chronic gastric and duodenal ulcers. It varies in amount from minute quantities, only discoverable by microscopical or chemical examination of vomitus and fæces, to 1 pt. or more, so that vomited matter containing blood may give no naked eye evidence, may be of a grayish color, resemble coffee grounds, present a bright-red appearance, or, from the presence of clots, be described by patients as containing "lumps like liver."

The frequent and repeated presence of small quantities of blood is the particular type of hemorrhage suggestive of chronic gastric ulcer. When blood is only discoverable by microscopic or chemical tests in vomitus or fæces, a cancerous, not a simple, ulcer should be suspected. Sudden, profuse, painless hematemesis in a young woman is quite unlikely to be due to a chronic ulcer, while in an elderly patient it is much more likely to be the result of cirrhosis of the liver.

Bleeding from a duodenal ulcer, if small in amount, easily escapes recognition as a cause of profound anæmia; if moderate in amount, and if careful examination of the fæces be made, it is usually indicated by a black or dark stool; and if free, blood vomiting may precede it. Profuse hemorrhage is accompanied by the usual symptoms of internal hemorrhage pallor, faintness and cold sweat—is followed shortly by a large black stool, and later, if recovery takes place, by weakness and anæmia.

In chronic gastric and duodenal ulcer, a profuse hemorrhage means the spread of the ulcerative process into some considerable vessel (Fig. 59), in the stomach, usually one of the arteries of the lesser curvature, in the duodenum the gastroduodenal artery, as it ies in relation to the inner wall. Such a hemorrhage is a serious matter

and not comparable to that occurring in acute ulcers, which, however profuse, usually stops spontaneously and is very seldom fatal.

There are three physical signs to which greater or less importance is attached in the diagnosis of uncomplicated chronic ulcer of the stomach or duodenum.

1. *A Tender Spot.*—Over the ulcer, whether in the stomach or duodenum, a *deep* well-localized tender spot is discoverable in the majority of cases. In front, in gastric ulcer it is situated on the left side of the

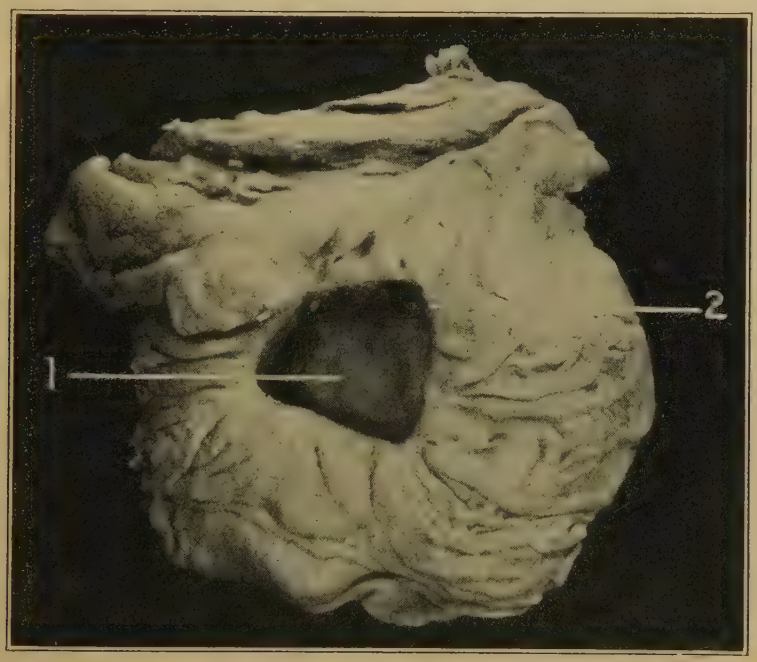

FIG. 59.—Chronic ulcer of the stomach, close to the lesser curve. 1, Liver tissue forming the base of the ulcer; 2, open mouth of vessel, from which fatal hemorrpage occurred.

epigastrium, whereas in duodenal ulcer it is usually to be found to the right of the middle line and a little above the umbilicus. Dorsal tenderness at the level of the tenth to twelfth thoracic vertebra, about 2 in. from the middle, has been described by some physicians as an important sign of chronic gastric and duodenal ulcers, as also tenderness of that vagus in the neck which supplies the portion of stomach or duodenum implicated by ulcer, but surgeons are apt to place most reliance on signs at the seat of disease and to doubt all others.

2. *Rigidity of the Overlying Muscles.*—Quite localized rigidity at the upper part of one or other rectus muscle will be found covering an active gastric or duodenal ulcer, and is an important sign.

3. *A Tumor.*—A tender nodule or an indefinite induration, especially in the neighborhood of the pylorus, with a history of long-standing stomach trouble, is characteristic of chronic ulcer, and furnishes its most important sign. A considerable tumor may be caused by inflammatory exudation and induration round a chronic ulcer, but this is rare. A definite nodular, hard, movable tumor suggests a cancerous rather than a simple ulcer.

Complications of Chronic Gastric and Duodenal Ulcers.—These depend upon three considerations:

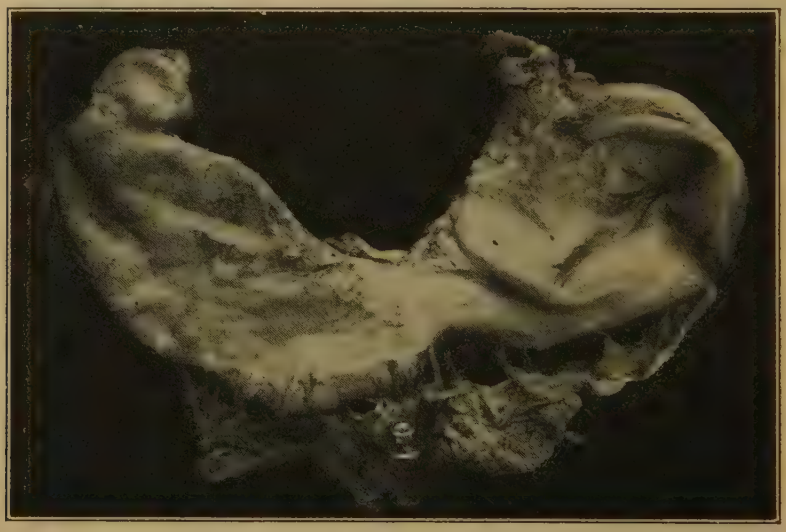

FIG. 60.—Hourglass stomach following healing of simple ulcer of the lesser curve.

1. Whether healing of the ulcer occurs, with extensive fibrosis.
2. Whether the ulcer continues to spread.
3. Whether further changes occur in the ulcer—secondary infection.

1. *Healing with cicatrization* produces results dependent on the site of the ulcer, *e.g.*, obstruction of the œsophagus when the ulcer is at the cardiac orifice (very rare); hour glass stomach when the ulcer is in the neighborhood of the midgastric sphincter (not uncommon) (Fig. 60); hypertrophy and dilatation when the ulcer is at or near the pylorus (frequent) (Fig. 61).

In the duodenum, ulceration, except in the first part, is a rare

event. Cicatrization of an ulcer in the usual position may produce the same conditions as if the pylorus were obstructed, viz., hypertrophy and dilatation of the stomach.

An ulcer in the second part has been known to involve the papilla of Santorini and, by cicatrization, cause obstruction of the common bile and pancreatic ducts.

2. *Continued spread of the ulcer* produces complications dependent on the direction of the spread and of the structures involved.

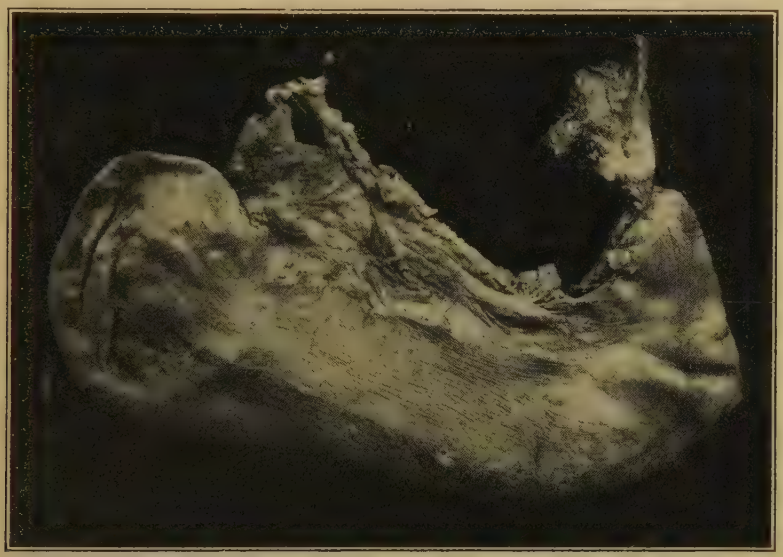

FIG. 61.—Simple stenosis of the pylorus, from healed ulcer, with dilatation of the stomach. Specimen viewed from behind.

The most important consequences of continued spread is perforation of the ulcer, which will be dealt with later.

Next in importance comes hemorrhage. The serious nature of this, as it is usually due to spread of the ulceration into a large neighboring vessel, has already been emphasized, but greater stress must now be laid upon it. In the earlier days of stomach surgery nearly all the progressive surgeons advocated operation for the arrest of hemorrhage from the stomach. Centuries of experience had not taught them that bleeding from the stomach rarely failed to stop spontaneously. Operative calamities, and they were not few, were necessary to convince them that they might be wrong. Now the pendulum has swung very far in the opposite direction, and whether the cause of the hemorrhage may be acute or chronic ulcer the majority of surgeons do not pause to enquire,

but refuse to operate for its arrest. Fortunately, active hemorrhage is a rare event in chronic ulcer, because the spread of an ulcer usually suffices to cause, in the larger vessels, by inflammatory changes in the wall, thrombosis and blocking in advance of the destruction wrought by the ulcer. If this has not occurred, a history similar to that produced by hemorrhage due to septic infection elsewhere may be expected. The patient will vomit a quantity of blood and recover; in a few days the attack will be repeated and it will be renewed again and again until the patient dies. The guiding rule for cases, in which symptoms of chronic ulcer, either gastric or duodenal, have preceded the hemorrhage, should be to operate as soon as the patient is sufficiently recovered from the first shock, with the object, if possible, of securing the bleeding point, or if this is not feasible, of performing gastroenterostomy.

Continued spread of the ulcer may involve neighboring viscera, *e.g.*, liver, pancreas, etc., and cause partial destruction of them, with erosion of their blood-vessels, etc. (Fig. 59).

Spread of ulceration to the peritoneum causes adhesions to surrounding parts, and, in rare cases, these may produce serious symptoms, though their function is to protect against perforation. Gastric and duodenal fistulæ, as a consequence of spread of the ulcer, have already been considered.

Malignant Changes in the Ulcer.—The most important known predisposing cause of cancer is chronic irritation and it is in accordance with this knowledge that cancer of the stomach has been found springing from a chronic ulcer. Indeed it is now the commonly accepted belief, but one which I do not share, that the great majority of cancers of the stomach are preceded by ulcer, and that this is the important element in their causation.

Mayo and Moynihan say that 50 to 70 per cent. of cases of carcinoma of the stomach arise in simple ulcers.

Perforation.—The most serious complication of both acute and chronic ulcers of the stomach and duodenum is perforation, and the symptoms when perforation has occurred are common to both. If the history is taken with every care, in the great majority of cases there is a story of definite "indigestion" preceding perforation, but in a small minority there is no evidence that the attack has followed any gastric disturbance at all. It is in these that I expect to find a typical acute ulcer. Where the usual history of "indigestion" has preceded perforation, the opening will be found within the area of a chronic ulcer. In the case of a chronic ulcer it may be possible to guess that perforation

is impending, and I have reported a case,[1] in which localized tenderness and rigidity over the duodenal ulcer led me to this diagnosis, and to a prognosis which was confirmed by perforation occurring four hours later. In the overwhelming majority of cases at the present time, perforation is the first indication the patient gets that there is anything seriously wrong, though this will diminish as a correct diagnosis takes the place of "indigestion."

Perforation usually occurs during the day, and often follows the ingestion of food or some activity. It commences so suddenly in many cases as to be compared to "a stab with a knife." The patients always recognize the serious condition which has so swiftly developed and almost all feel that they are going to die. This "deadly" character of the pain is one to which I attach the greatest importance in the history. The acute pain is followed immediately by an illness which may be divided into three stages.

The first is immediate and due to shock, presenting its clinical manifestations, viz., pallor, weakness, chilliness, sweating skin and feeble pulse; the second, recovery from this; and the third, the stage of infection—peritonitis.

Death may occur in the first stage from profound shock. I have seen it occur in two cases, but, more commonly, this stage is so transient that its importance runs the risk of non-recognition. As a rule the symptoms of shock last for one or two hours, then reaction follows. Vomiting generally occurs, but it is seldom a prominent symptom. During the period of reaction the patient may feel and look so much better, as to deceive himself and his friends into the belief that the trouble is all over, and that complete recovery is just a matter of time. This belief is soon upset by the advent of peritonitis, and in the great majority of cases death follows in a few days. It is especially during the second stage that mistakes in diagnosis are made, because it is difficult to believe then, that some of these patients are suffering from such a serious lesion as perforation is, when they look and feel so well.

Physical Signs.—*On inspection*, immobility of the upper abdomen is the noticeable feature, and respiration, though increased in rate, is entirely thoracic. Distention occurs only in the earlier stages, if an unusual quantity of gas has been discharged through the perforation.

On palpation, there is a board-like rigidity, at first localized to the upper part of the abdomen, and all the time most marked there, though

[1] Clinical Journal, Nov. 10, 1909.

later, with the development of peritonitis, appearing wherever the peritoneum is infected. Tenderness, at first localized and later diffuse, accompanies the rigidity.

On percussion, two important points should be remembered:

1. The presence or absence of liver dulness. If liver dulness is present at first and, an hour or two later, is discovered to have disappeared, and become replaced by a tympanitic note, the sign is then one of first rate importance. It signifies the presence of free gas in the peritoneum and a perforation. No other record regarding liver dulness is reliable.

2. Evidence of the presence of free fluid. Rarely there is a sufficient escape of fluid from the stomach; more commonly sufficient is secreted by the irritated peritoneum, to cause dulness at the dependent parts of the abdomen, which shifts on a change of position. With the patient recumbent and on his back, a dulness in both flanks will be noted, shifting to the dependent side over an increased area when the patient turns, and becoming replaced by a tympanitic note in the upper flank.

Diagnosis of perforation of stomach or duodenum.

The points to which I attach much importance in diagnosis are:

1. The history of previous "painful indigestion," rarely absent.

2. The severity and deadly character of the initial pain, and its location in the epigastrium.

3. Rigidity and tenderness of the abdominal wall. I find that my assistants all soon learn to attach very great importance to the presence of muscular rigidity.

4. The signs of free fluid in the belly.

5. A steadily rising pulse. In doubtful cases a half-hour record of this should be kept.

6. Absence of liver dulness, with the limitations mentioned above.

After six months experience in our surgical wards, house surgeons rarely make mistakes in the diagnosis of a perforation, and seldom fail to say where the lesion is, *i.e.*, gastric or duodenal. There is little excuse for the large number of mistakes made in these cases.

Prognosis.—All textbooks offer a most gloomy prognosis for perforating ulcer of the stomach or duodenum unless surgical aid has been immediately forthcoming. This has served the very good purpose of directing attention to the value and importance of early operation. No serious surgical condition has afforded such a brilliant response to modern surgery, and the need for and value of early operation are now universally accepted. The prognosis of cases left alone is, however,

not so bad as has been stated, and I am satisfied that perforations in both stomach and duodenum can recover without surgical aid. In a clinical lecture[1] I discussed this problem at some length and quoted cases to support my belief. The results of perforation naturally vary with the amount and quality of material extravasated and the rate of its extravasation. The most virulent peritonitis will be rapidly caused by extravasation of the contents of a dilated septic stomach with pyloric stricture; localized reaction is likely to follow the perforation of a fairly healthy empty duodenum. In the usual and worst cases general septic peritonitis develops, and death, though not constant, is the expected result. In all these conditions recovery is likely to be followed by dense adhesions, because the peritoneal endothelial lining has been destroyed by the inflammation, produced by extravasation of gastric or duodenal contents. These, in the normal stomach and duodenum, are, if septic at all, only moderately so, because the acid gastric juice possesses sufficient antiseptic quality to destroy an ordinary number and quality of organisms. The stomach and duodenum in ulcer cases are, however, not healthy; indeed the ulceration is usually only part of a more diffuse septic inflammation. The prognosis varies then with the amount—large or small—and the quality —virulent or otherwise—of the extravasation. It also depends upon the position of the perforation and its size. Size has mostly to do with the quantity of matter extravasated, position with the path the infective matter has to follow.

A perforation on the anterior gastric wall, the usual site, opens into the general peritoneal cavity and soon spreads through the whole of it. One on the posterior wall opens into the lesser sac and, until the extravasated matter escapes through the foramen of Winslow, does not infect the general cavity. A perforated duodenum first pours its contents into the hepatic pouch,[2] and, when this runs over, they escape down the gutter on the outer side of the ascending colon into the right iliac fossa and so on into the pelvis. The peritonitis set up in this course, and in the right iliac fossa, often leads to a mistaken diagnosis of appendicitis by surgeons who pay insufficient attention to a history of the previous health and of the early symptoms of their patients. Position may also allow of contact with parts favorable to adhesions, *e.g.*, the liver and gall-bladder often seal perforations of the pylorus and duodenum, while an ulcer on the anterior wall of the stomach has little chance of natural cure by such means.

[1] Clinical Journal, Nov. 10, 1909.
[2] B. M. J., Nov. 3, 1894.

Far above all else, prognosis depends upon the time that elapses between perforation and operation. To prove this, in introducing a discussion on general peritonitis at the Annual Meeting of the British Medical Association[1] I presented some recent figures, as follows, from the Royal Victoria Infirmary, Newcastle-upon-Tyne. Of 36 cases of ruptured duodenal ulcer, three were admitted so ill with septic peritonitis that they died shortly after admission without operation. The diagnosis was made in each case and was verified by post-mortem examination. Six patients died after operation, three of them from general septic peritonitis and three from septic broncho-pneumonia.

The time at which operation was performed was divided into stated periods thus:

	Operations	Deaths
At 6 hours and under	11	0
Over 6 and under 12 hours	6	0
Over 12 and under 24 hours	8	2
Over 24 and under 48 hours	5	3
Over 48 hours (all cases admitted)	6	4

In the two cases of over 48 hours' duration which recovered, the perforation had been entirely excluded, by adhesions, from the general peritoneal cavity. Three of the deaths were in patients too ill to operate upon.

Of 16 cases of ruptured gastric ulcer, 12 recovered and four died from general septic peritonitis, verified in each case by post-mortem examination.

	Operations	Deaths
At 6 hours and under	3	0
Over 6 hours and under 12	7	1
Over 12 hours and under 24	1	0
Over 24 hours and under 48	2	2
Over 48 hours	3[2]	1

Treatment.—The treatment is early operation. There is abundant proof of the importance of this, but it still requires to be emphasized.

The main object of the operation is to *deal with the primary focus*, in other words to stop the leak. The operation should, when at all possible, be done in a properly equipped hospital, because it is unfair to the patient to attempt such an operation in any private house. As soon as possible the patient should be warmly wrapped up on a stretcher, put

[1] B. M. J., Oct. 28, 1911.

[2] Of the three cases admitted of more than 48 hours' duration, one case was of a week's duration, was moribund, and died immediately after admission without operation. In the two cases which recovered, operation showed that the perforation was occluded by adhesions.

in an ambulance, and sent off. It is well at the same time to administer a hypodermic injection of morphia, and a note that this has been done should accompany the patient. Objection has been raised to this course that a journey adds to the danger by increasing shock. Our experience is a sufficient answer to this. The added danger is trifling, the increased mortality of operations done at home is a serious one.

The incision I prefer is a midline one in the epigastrium, and often includes the umbilicus, which is excised by an elliptical extension of it. The ulcer is sought for and is usually readily found. The escape of gas or of the visceral contents, or, later, a patch of purulent lymph, makes its discovery easy. Failing to find it at the usual sites in stomach or duodenum, the posterior wall of the stomach is explored by tearing through the gastrohepatic or gastrocolic omentum. The perforation is first closed by interrupted sutures of thick catgut through all the coats and this layer is buried by an outer row of interrupted or continuous Lembert sutures of thin silk. A purse-string suture may be used for the deeper layer if the opening is small and the wall surrounding is sufficiently yielding, but this is an unusually favorable combination. If the suture will not hold, it is necessary to close the opening by suturing a piece of omentum or an adjoining viscus over it.

Difficulties that may appear insurmountable often disappear if the parietal incision is enlarged.

Cleansing the Peritoneum.—There is difference of opinion as to the need for this, and many surgeons believe that attempts at cleansing are futile and may be mischievous, often spreading localized dirt far and wide. My own practice is to avoid irrigation and to gently wipe away *local* extravasation with mops wrung out of warm normal saline solution (ʒi of sodium chloride to 1 pint of water) when it is limited; but when the operation has been done early and extravasation has occurred widely in the peritoneum, then I remove as much as possible by irrigation. The first step then is to introduce a glass tube through a small independent opening above the pubis, into the bottom of the pelvic peritoneal pouch. The tube of the irrigator is next passed up to the diaphragm, and every nook and corner flushed out with normal salt solution at a temperature of 100°F., with the shoulders of the patient raised. This can be carried out during the time occupied in closing the leak. I entertain no doubt that, by this measure, not only are lives saved, but subdiaphragmatic and pelvic abscesses and intestinal obstruction are prevented. It is always necessary to close the drainage

opening with a suture when the tube is taken out, for in one case[1] a patient of mine died from failure to recognize its importance.

Drainage.—With regard to this there are also considerable differences of opinion. My own view is that in the majority of cases, and especially early ones, drainage is useless and may be injurious. After irrigation I usually remove the tube at once. If dirty matter, likely to cause peritonitis, such as escapes from a dilated septic stomach, has been extravasated, I drain. I would also drain in the presence of an active diffuse peritonitis, or if there was any doubt about the security of the suture. The next question to be answered is "how much to drain." Patients are, I believe, killed by too much drainage. I do not remember having seen a patient with a tube in the epigastrium, another above the pubis, and one in each flank, get better, and, if he did, I think it would be in spite of this surgical activity. My belief is that, with the patient in the sitting posture, a single drainage tube above the pubis, and reaching the floor of the pelvis, will drain off everything that can be drained, if it is regularly emptied by the Lawson Tait syringe. The only exception to this is when doubt is felt regarding the competence of the suture, and then a second tube should reach from the neighborhood of the suture line to the epigastric incision. If seen early, some of these patients, as has already been pointed out, are suffering severely from shock, and the question arises as to what should be done with them. There can be no doubt that unless they are obviously dying it is best to operate at once. As soon as the abdomen is opened and the irritating contents of the peritoneum escape, many of them improve. If no morphia has been given, a quarter of a grain hypodermically, along with $\frac{1}{120}$ gr. of atropine, before commencing the operation, may work wonders. During the operation normal saline solution, in my cases, is slowly introduced into a vein, continuing until the pulse improves or two pints have been given. An alternative is to administer the same under the skin. At the completion of the operation and before the patient is sent to the ward, 1 pt. of coffee and 2 teaspoonfuls of sugar are introduced by enema into the colon.

The question as to whether gastroenterostomy should or should not be done, after the ulcer has been closed, has been much discussed, and many surgeons now say that it should be done in every case. This is not my belief. The ordinary operation for closure of the ulcer is so simple that it can be done successfully by anyone possessed of a knowledge of surgical principles, and with proper control of his hands

[1] Clinical Journal, Nov. 10, 1909.

and head, and this knowledge has been of great service to the community. If gastroenterostomy is essential, the operation is one to be undertaken by surgical experts only, so that the answer to the question is a grave one, involving great responsibility. My view is that the only essential is to close the leak, and that it is better to have the patient almost certainly recover with chronic ulcer, than to run the additional risk of an added gastroenterostomy. If gastroenterostomy is required later, and in more than 50 per cent. of cases it is not, it can then be done with safety. My own practice, however, is to perform gastroenterostomy always, when there is obstruction to the flow of visceral contents, produced either by the disease or by the necessary infolding to close the leak. I also do it in early cases in good condition, when a *chronic* ulcer has perforated. Guided by the generally useful surgical principle, to avoid more operating than is essential to save life, in the presence of active sepsis, I refuse to do gastroenterostomy in cases perforated more than a few hours, where septic peritonitis is present.

Three other methods may be very useful additions to the ordinary operations. I refer to pyloroplasty, when the operation involves the pylorus,[1] gastroplasty when the perforation occurs in an hour-glass stomach, and gastrostomy when the patient is very ill. My colleague, Mr. W. G. Richardson, is the originator of this last method,[2] and it is one deserving of more recognition than it has yet received. Instead of closing the perforation, he passes an india-rubber catheter into the stomach through the perforation, fixes the stomach to the parietes, and washes out the stomach and feeds the patient through the tube. After a few days the tube is taken out and the opening has shortly closed spontaneously in the great majority of cases so treated.

In late cases, when general peritonitis has become fully established and the abdomen is tense and distended, operation will generally do more harm than good, and some of these very ill patients can recover if helped to do so.[3] They are sat up, nothing is given to them by the mouth, constant heat is applied to their abdomen, saline solution is administered per rectum, the stomach is washed out for sickness, and small doses of morphia are used to allay pain and to secure rest.

[1] Miles, Edinburgh Medical Journal, Aug. and Sept., 1906.
[3] Northumberland and Durham Medical Journal, Nov. 12, 1903.
[2] General Peritonitis, B. M. I., Oct. 28, 1911.

NEOPLASMS.

Simple Tumors of the Stomach.—These are relatively rare and, as is the case with simple tumors elsewhere, their symptoms are produced either by mechanical effects or by complications.

According to their structure they may be classified as (*a*) glandular, (*b*) derived from connective tissue.

Glandular.—Adenoma.—Adenomata may be single or multiple, may occur at any part, though favoring the neighborhood of the pylorus and may be sessile or pedunculated, forming polypi, their favorite type. They are pink or brownish in color, globular, or lobulated in shape, and present the usual glandular structure. Ebstein[1] collected 24 cases forming polypi. They occur nearly twice as often in men as in women; their frequency increases after 40 years of age; in half the number the tumors were solitary and in the remainder multiple, even up t 200. They are seldom of practical importance, but in other parts, especially the colon, they have so often been found associated with malignant disease as to rank as an important predisposing cause.

Connective Tissue Tumors.

1. Myoma and fibromyoma.
2. Fibroma.
3. Lipoma and lipomyoma.
4. Lymphadenoma.

1. Myoma and fibromyoma resemble similar tumors in the uterus and arise from the muscle coats. They may remain interstitial, or grow toward the stomach cavity or peritoneal surface, forming sessile or pedunculated tumors, occasionally of very large size.[2]

2. Fibromata are usually single and pedunculated, smooth or lobulated, and grow from the submucous tissue. They also may reach a large size.

3. Lipomata and lipomyomata are extremely rare and may be either submucous or subperitoneal.

4. Lymphadenoma is chiefly of pathological interest and is rare. It gives rise to the appearance of multiple polypoid projections into the cavity of the stomach.[3]

The complications which cause symptoms are: (1) injury, (2) inflammation, (3) mechanical disturbances, (4) degenerations, including malignancy.

[1] Archiv. of Anatomy and Physiology, 1864, Keen.
[2] Erlach, Wien Klin. Woch., 1895, Nov. 15.
[3] Diseases of the Stomach, Robson and Moynihan.

Injury and inflammation are especially liable to lead to ulceration with its associated symptoms, in particular, hemorrhage. Either sarcoma or carcinoma can be preceded by simple tumors, which here, as elsewhere, predispose to malignancy.

If a tumor can be felt a diagnosis is possible, but has seldom been made, and these conditions have nearly all been discovered after operation. Gastrotomy with excision of polypi, excision of the affected portion of the stomach-wall, and partial gastrectomy are the operations which have been performed for their removal.

Cysts, simple and malignant, have been found in the stomach-wall. Mucous retention cysts, serous, blood, chylous, dermoid and hydatid cysts, and cystic degeneration of lymphangioma are the recorded simple varieties. In connection with malignant growths, cysts due to degeneration and to hemorrhage are occasionally found, but all are rare. Like the solid tumors their diagnosis is seldom made before operation, and they require the same measures, with the exception that some of the simple cysts can be cured by drainage.

Malignant Tumors of the Stomach and Duodenum.—Sarcoma is rarer than carcinoma, but is not so uncommon as has been usually taught. Fenwick[1] believes sarcomata account for 5 to 8 per cent. of primary growths in the stomach. The varieties recorded have been round- and spindle-celled, myo and angiosarcoma, with considerably over half of them of the round-celled variety. Sarcoma generally appears as a diffuse infiltration of the pyloric end of the stomach, which more usually makes the pyloric orifice patulous than constricts it. A circumscribed tumor is rare, a diffuse one is usual, and the growth may involve the entire stomach, spreading, unlike carcinoma, into both duodenum and œsophagus. When the growth is circumscribed it may reach a large size and is likely to be of the spindle-celled variety. Sarcomata of the stomach may occur at any age. Their diagnosis is difficult, and can only be guessed at after the discovery of the tumor. The treatment is gastrectomy, either partial or complete, and the prognosis the same as that of sarcomata everywhere.

Sarcoma of the duodenum is extremely rare.

Cancer of the Stomach.—Since the pioneer work of Billroth has encouraged surgeons to undertake operations for the relief or cure of these desperate cases, the early diagnosis of cancer of the stomach has become one of great interest and importance.

[1] Diseases of the Stomach.

Horsley Drummond[1] has made a careful analysis of our cases, 160 in number, and the conclusions he arrived at agree so closely with published statistics that I have adopted them as my guide.

Sex.—Males are attacked more than twice as frequently as females.

Age.—Cancer is found as early as 19 and as late as 74, the average being 53.2. In women it occurs earlier than in men.

Site.—Considerably over half commence in the pyloric end of the stomach, about 10 per cent. in the lesser curve alone, and about 30 per cent. in the remainder of the stomach. In about 5 per cent. the stomach is diffusely infiltrated, and the cardiac orifice is attacked in 8.8 per cent.

FIG. 62.—Carcinoma of the pylorus—annular type—producing obstruction and dilatation of the stomach.

Types.—In the stomach, as in other parts of the alimentary canal, four types of carcinoma are to be found.

1. *The annular type*—the most common—and the usual variety found at the pylorus (Fig. 62). It forms a circular growth constricting the outlet, ceasing abruptly at the pyloric ring, and not invading the duodenum. The adjacent stomach-wall is progressively infiltrated and thickened, and the disease spreads with greatest rapidity along the lesser curvature. The chief spread is in the submucous tissue and extends to some distance beyond the palpable edge of the growth, a fact to be remembered in performing excision of it. Obstruction of the

[1] Newcastle Division, North of England Branch, British Medical Association, Dec. 20, 1912.

pyloric outlet produces the same effects as in a simple stricture, *i.e.*, first, hypertrophy of the muscular coat and contraction of the stomach cavity, and, later, dilatation. Inflammation of the mucous coat proximal to the obstruction follows, and ulceration of the mucous membrane is a likely result. Fibrous contraction in the growth may produce puckering of the peritoneal coat over it. This form of growth in the midstomach produces hour-glass contraction, and at the cardiac

FIG. 63.—Typical crateriform carcinomatous ulcer of the "gastric mill." 1, cardiac orifice; 2, pylorus; 3, carcinomatous ulcer; 4, secondary glands on lesser curve, the large nearer the growth; 5, transverse colon adherent and strictured, but not perforated.

end may block the inlet and produco symptoms of œsophageal obstruction.

2. *Fungating Tumor.*—Owing to the smaller quantity of fibrous tissue present, no constriction accompanies this variety of growth and its development is rapid. A soft friable mass with infiltrated base projects into the cavity of the stomach and the growth readily ulcerates and bleeds. The most striking symptoms may be anæmia and loss of strength, with little to draw attention to the stomach as the seat of mischief.

3. *Crateriform Ulcer.*—This is the typical cancerous ulcer, *i.e.*, one showing growth in excess of destruction (Fig. 63). Its surface is roughly nodular, its edge hard, raised, and everted, its base shows marked infiltration, often puckering the peritoneal coat covering it, and the discharge from it is foul and hemorrhagic.

4. *Diffuse Infiltration.*—This rare variety thickens and contracts the stomach, giving rise to the malignant variety of "leather bottle" stomach (Fig. 64).

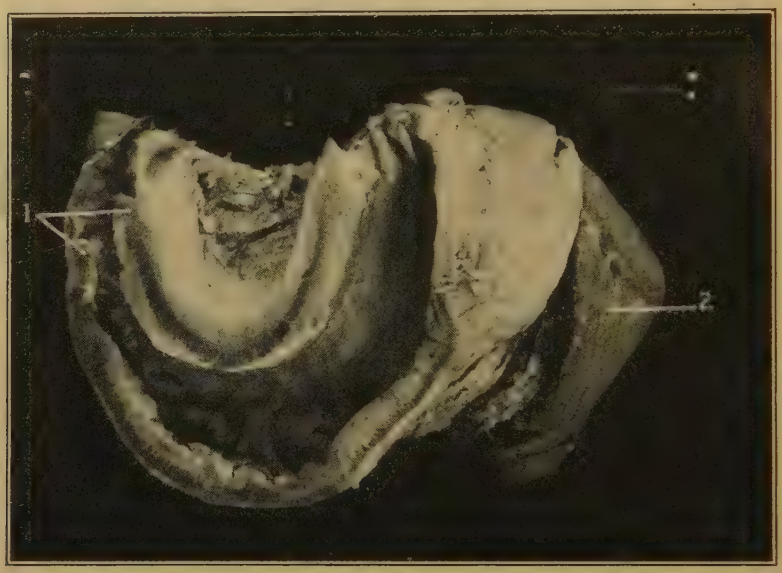

FIG. 64.—Diffuse carcinoma of the stomach—"leather bottle" stomach. 1, Pylorus; 2, spleen. Note the great thickness of stomach walls.

Microscopic Characters.—The type of cell present may be spheroidal columnar, or squamous.

Spheroidal-celled carcinoma is the common type and occurs in about two-thirds of the cases.

Columnar-celled carcinoma constitutes about one-third of the cases and is an atypical growth springing from the glandular tissues.

Either of these may be of the scirrhous or the encephaloid type of cancer, according to the amount of fibrous tissue present, but the spheroidal-celled variety is more likely to be fibrous, scirrhous, and constricting, and the columnar fungating, encephaloid, and an ulcerating tumor.

"Colloid degeneration" occasionally affects cancers of the stomach

as it does cancers in other parts of the body. It is produced by the transformation of the tissues of the growth into a gelatinous, semi-translucent, mucoid material, which forms a large, diffuse, infiltrating tumor, apt to spread widely, especially into the omentum.

Squamous-celled carcinoma is uncommon and commences at the cardiac end or spreads from the œsophagus.

Secondary cancer of the stomach is much rarer than the primary variety. It may arise by direct extension of a growth, *e.g.*, of the œsophagus; from contiguity, *e.g.*, pancreas, gall-bladder, colon, etc.; by conveyance from distant parts, *e.g.*, breast, uterus, kidney, etc.; and by grafting, *e.g.*, swallowing of cancerous particles when the primary lesion is in the mouth or pharynx.

Extension of the Disease; Local.—1. *By Continuity of Tissue.*—The disease, as has already been mentioned, extends more in the submucous than in the other coats. The infiltration ceases abruptly at the pylorus, seldom advancing into the duodenum, while in the opposite direction the lesser curvature is rapidly and extensively invaded along the line of the main lymphatics. Spreading deeply, the muscular and then the peritoneal coats are attacked. When the peritoneum is reached, cancer cells may be cast off into the peritoneal cavity. These may, by gravity, fall into the pelvis and, growing there, form deposits, which may be felt from the rectum or the vagina, and serve as useful aids in diagnosis and prognosis.[1] If the general peritoneum is affected, "Omental cakes" and tumors, or ascites, may develop. If adhesions occur at the site of peritoneal invasion, the stomach becomes glued to neighboring structures and the disease spreads into them, forming hepatic, pancreatic, parietal, and colic growths, and possibly fistulæ.

2. *By Lymphatic Spread.*—The lesser curve lymphatics and glands are soonest invaded and, as these accompany the coronary vessels, extension early occurs up to the cardiac orifice. The next most likely to be affected is the cœliac group, and from these extension to the receptaculum chyli and thoracic duct is apt to occur. It is to this that an enlargement of the glands in the lower posterior triangle of the neck, to which great diagnostic and prognostic importance is attached, is due. If extension occurs to the hepatic group, situated about the transverse fissure of the liver, either jaundice or ascites or both may result, from pressure on the portal vein and bile duct.

3. *Through contact, i.e.*, direct transmission. This is seen when the abdominal wall opposite a growth of the stomach, or the structures

[1] G. Grey Turner, B. M. J., Feb. 3, 1912.

surrounding the stomach, become involved without the intervention of adhesions, and apart from lymphatic or blood spread.

General.—Dissemination of the carcinoma can occur either through the lymphatic- or blood-stream, in the former through the thoracic duct and in the latter by the portal vein.

Symptoms.—In many cases it is not difficult to make a diagnosis of cancer of the stomach at a glance, but these are already likely to be so hopelessly advanced that nothing can be done for them. The most hopeful cases are those in which obstruction at the pyloric orifice occurs early and the urgency of the symptoms drives the patient to seek advice. A growth at either orifice is likely to produce obstruction. When at the cardiac end, the symptoms are those of œsophageal stricture, and, at the pyloric end, those of dilatation of the stomach. It is often difficult to say whether the patient is suffering from cancer or chronic ulcer, and the diagnosis generally lies between these two. Apart from the history and the physical signs I always attach very great importance to the general appearance of the patient. Many chronic ulcer cases look very ill and thin and feeble, but they seldom have the completely played out, faded appearance of the cancerous patient. I have been accustomed to teach as a general rule that in chronic ulcer the sequence of events is pain, vomiting, asthenia, whereas in cancer this order is reversed and the patient first feels weak and ill, then vomiting frequently appears, and pain relatively late or perhaps not at all. It has already been pointed out that the patient with ulcer has an appetite and would eat if he dare. Loss of the taste for food is common in cancer.

Pain is present in 90 per cent. of cases. It is most marked in cases where the lesser curvature is involved and comes on earlier than that felt in disease at other parts of the stomach. The pain has not the strict relationship to food that we expect in chronic ulcer, is more continuous, and is not so entirely relieved by vomiting.

Tenderness and rigidity over the tumor are rarely present and are never so marked as in chronic ulcer.

Vomiting occurs as a marked symptom in 73 per cent. of cases. In pyloric cases it is often large in amount. The vomited matter in 85 per cent. of cases has much diminished or absent free HCl, and in advanced cases lactic acid or portions of growths are sometimes found.

Blood.—Hematemesis or melæna occurs in 35 to 40 per cent. (Hale White). Typical bleeding is the constant presence of a small,

perhaps microscopic, quantity. It is quite rare to have a large hemorrhage in carcinoma, but it can occur in fatal quantity.

Tumor.—This could be palpated in 80 per cent. of our cases and varied in situation according to the part of the stomach involved. Its definition, mobility, and absence of tenderness, are the chief points to note in distinguishing it from inflammatory swellings. The presence of a tumor in most cases denotes extension beyond the primary focus.

Dilatation of the Stomach and Hour-glass Stomach.—These depend upon obstruction at the pylorus or near the midstomach respectively. The amount of dilatation is rarely equal to that produced by simple stricture, as it is produced with greater rapidity. Succussion and visible peristaltic movements may be present.

Dysphagia may result from obstruction to the cardiac orifice and simulate an œsophageal stricture.

In the later stages of the disease, in addition to progressive emaciation and anæmia, signs of extension beyond the primary focus may be found—enlargement of the left supraclavicular glands, deposits in the pelvis or at the umbilicus, secondary deposits in the peritoneum, omentum, or liver, with or without jaundice or ascites, perforation of the stomach ulcer, etc.

Diagnosis.—The chief difficulty is to distinguish cancerous from simple ulcer. In discussing the symptoms many of the chief points have been mentioned. One of the most important in my view is the history of the patient. The greatest authorities teach that in a large percentage of cases ulcer precedes cancer; Graham (Mayo Clinic) says in 62 per cent. of cases, and he is supported by the experience of Moynihan and others. Though we expected in accordance with the knowledge that chronic irritation is the most frequent precursor of cancer, to find that this was true, we were surprised to find that in our cases a history suggestive of chronic ulcer could be obtained only in 11.3 per cent. The usual story is that these cancer patients have had exceptionally little trouble with their stomachs until they were attacked by cancer. We have consequently come to regard a history of long-standing stomach trouble as the most important evidence against malignancy. This belief has been confirmed by the subsequent history of my cases of gastroenterostomy, when no excision of the ulcer has been done, for cancer has not developed in more than 1 per cent. of instances, in which simple chronic ulcer was the diagnosis made before and after operation.

Every surgeon who writes on this subject deplores the late stage at

which he sees cases of cancer of the stomach. The fact must be remembered that, except in these cases where the orifices are early obstructed, there are often no symptoms or signs sufficiently marked to suggest a serious lesion. I have explored, "early," several cases of cancer of the lesser curvature of the stomach, in which the symptoms were so mild and the patient in such apparently good health, that it seemed doubtful whether an operation were justified, only to find disease so advanced that nothing surgical could be done for it. Elderly patients with recent "indigestion," which does not quickly yield to ordinary treatment, should undergo exploratory operations. I have on several occasions avoided laparotomy and cleared up a doubtful diagnosis by removal of an enlarged supraclavicular gland with a local anæsthetic and subsequent microscopical examination.

Treatment.—Palliative treatment consists in attention to the diet, the administration of digestives such as hydrochloric acid and pepsin, lavage of the stomach, and the careful daily use of opium, alcohol, and castor oil. Our statistics show the average duration of life to amount to 8.8 months after the apparent commencement of the disease.

Operation may be palliative (gastroenterostomy) or radical (gastrectomy).

Gastroenterostomy brings relief in the cases when it is definitely indicated from the presence of obstruction at the pylorus, but in no other circumstances is it at all useful. Life in suitable cases is probably prolonged by it for about six months. It has proved to be so unsatisfactory an operation in cancer that it would probably long ago have become disregarded, if, every now and again, cases of inflammatory tumor, due to chronic ulcer, had not been mistaken for cancer and cured by it. Its best use in cancer cases is to act as the first step in the radical operation. In very feeble patients it gives a chance of so much improvement from arresting their vomiting, allowing some feeding to be done, and draining the stomach, that a radical operation may be possible, with some chance of success, from 10 to 20 days later. It is many years since I expressed the belief that gastrectomy even as a palliative was a more satisfactory operation.[1]

The ideal operation is that for cancer everywhere, viz., to remove widely the primary focus and the whole of the lymphatic area into which it drains. The impossibility of doing this in the overwhelming majority of cases explains the failures from cancer operations. For cancer of the pylorus, partial gastrectomy, preceded or followed by

[1] Lancet, 1899, Vol. I, p. 901.

gastroenterostomy, is the operation of choice. All of the lesser curve of the stomach with its lymphatics and glands, and that portion of the greater curvature to a line drawn vertically downward from the cardiac orifice, with the corresponding portion of gastrocolic omentum and as many of the accompanying and surrounding lymphatics as are accessible, are excised by an extension of the operation known as Billroth's No. 2 (Fig. 65). The average duration of life after this operation has been, in a large series of cases, 18 months. Mayo up to 1906 reported 29 per cent. of his cases alive and well after three years, and

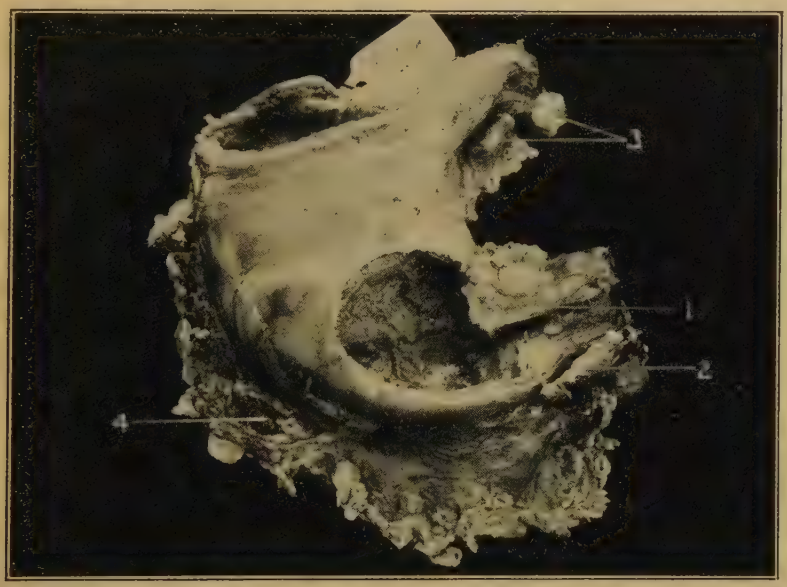

FIG. 65.—Specimen viewed from behind showing the extent of the operation in "partial gastrectomy." 1, Carcinoma involving the pylorus; 2, subpyloric glands secondarily involved; 3, glands of lesser curve, secondarily involved; 4, gland in great omentum, not infected with carcinoma.

Paterson[1] found 14 per cent. alive after five years. The immediate mortality varies with the skill of the operator from 10 to 40 per cent. averaging 22 per cent., but this is much higher than it ought to be, or will be in the future. My own experience has been disappointing, but as I know of two patients who were in a very bad way at the time of operation, and who are now alive and well more than five years later, I have had some encouragement. If it had not been for the statistics of others and this experience, I would by this time have come frankly to regard the operations done, as palliative only, but, even so, as fully

[1] Hunterian Lectures, 1906.

justified. The relief afforded, and the prolongation of life effected, are ample recompense for the risks and trouble of the operation. One patient of mine, at the time of the operation, in continuous pain and vomiting everything he took, worked for 15 months in the mines in apparently full health and strength after partial gastrectomy, done in the presence of multiple small secondary nodules of cancer in his liver. Many others as ill have been equally relieved by the removal of their primary growths.

Recorded cases have proved that patients can live and can be cured of their cancer by removal of their whole stomach, so that it is difficult to place a limit to the possibilities in any given case.

Cancer of the cardiac orifice, in the present stage of knowledge, can be treated only by a palliative gastrostomy to relieve obstruction to swallowing.

Linitis Plastica—Cirrhosis of the Stomach.—A peculiar condition of the stomach has been described under this name, as "leather bottle" stomach, or fibromatosis of the stomach.[1] It has frequently been mistaken for cancer, may be localized or diffuse, and is probably always the result of chronic ulceration and infective inflammation. Though said to be simple in more than 50 per cent. of cases, it is frequently associated with cancer and should be treated by gastrectomy. This is the condition, previously referred to, as being considered cancer and cured after gastroenterostomy.

Carcinoma of the Duodenum.—Relatively to cancer of the stomach, cancer of the duodenum is a rare disease. When it does occur, in 70 per cent. of cases it involves the bile papilla. The growth forms a tumor, not larger than a hazelnut, of hard consistency, grayish white color, and cutting like a breast scirrhus. Microscopically it is a columnar-celled carcinoma. The common bile duct is early blocked and jaundice, except in the earliest stage, when it may intermit, is permanent and increasing, the gall-bladder being distended and palpable as a hard swelling under the right costal margin. (These signs are also found in cases of malignant disease of the head of the pancreas.) The pancreatic duct may or may not be obstructed and, when it is, nutrition is seriously affected.

Considering recent surgical advances and the fact that this carcinoma is of slow growth, remains localized for a long time, and affects the glands late, it is important to realize the possibilities of successful surgical interference. In the early cases a free local removal suffices.

[1] Alexis Thomson, Edinburgh Medical Journal, July, 1913

In any case, if an inoperable growth is found, a palliative cholecystenterostomy is the best treatment. When the malignant growth occurs above the outlet of the common bile and pancreatic ducts and causes stenosis, the symptoms are similar to those produced by cancer of the pylorus; on the other hand, when it occurs below and causes obstruction, the stomach becomes dilated as in the other condition, but the vomited matter is likely to have in it bile and pancreatic juice, and rapid emaciation follows.

Deformities.—*Dilatation, Hour-glass Contraction, Etc.*—We have already considered many of the phenomena associated with obstruction of the pylorus, but the great surgical importance of it makes special consideration desirable.

Dilatation of the Stomach.—Atonic dilatation and that due to spasm of the pylorus, from whatever cause arising, are more of medical than surgical interest, if, perhaps, we except that variety thought to be due to disease in the vermiform appendix and cured by appendicectomy.

Organic obstruction is the ordinary cause of dilatation of the stomach and cicatricial contraction, the result of a healed or healing ulcer, is its usual precursor (Fig. 61). Other causes are tumors in the pylorus or duodenum, or very rarely, distortion from tumors or adhesions outside.

The ordinary history of cicatricial stenosis followed by dilatation is, in the first stage, the usual one of years of "painful indigestion," with periods of entire relief—the ulcer stage. Then follows a second stage—ulceration with some contraction of the pylorus—when the hypertrophied stomach-wall is still able to compensate for the obstruction, if sufficient care be taken as to the quantity and quality of the food. In this, pain is the predominant feature, vomiting is readily produced, and the pain is at once relieved by it. Finally, in the third stage—that of dilatation produced by cicatrization—vomiting becomes the predominant sign, and pain is replaced by a feeling of fulness and uneasiness, unless some active ulceration is still going on. The vomiting is characteristic of dilatation. It occurs in large quantities, usually not more than once in the day, and frequently toward evening. The vomited matter is sour-smelling, yeasty, grayish brown in color, frothy and fermenting. Particles of food, which may have been partaken of days previously, may be recognized in it; indeed the fact that vomiting occurs mostly in the evening is due to this, viz., that the stomach does not empty itself, and each meal during the day adds to the accumulation. The starved and poisoned possessor of such a stomach becomes emaci-

ated and feeble, and suffers much from constipation and thirst. In some cases tetany develops, adding danger to the already serious situation, but lavage followed by operative relief of the obstruction may still, even then, bring about recovery.

Signs. Inspection.—The distended stomach may show itself as an epigastric swelling and, if not, this can be produced by the administration of a Seidlitz powder. Peristalsis from left to right may be observable. A nodule or tumor, which moves downward on forced inspiration,may be visible through the thin abdominal wall.

Fig. 66.—Congenital hypertrophic stenosis of the pylorus. 1, Enormous increase of the muscular tissue of the pyloric canal; 2, duodenum. Specimen viewed from behind (Museum of Hospital for Sick Children, Newcastle-upon-Tyne).

Palpation.—The presence of a nodule or tumor at the pylorus may be discovered. Prolonged succussion sounds can be produced by baking movements over the stomach-wall.

Percussion and auscultatory percussion show increased size of the stomach cavity.

Lavage.—The normal adult stomach holds between 2 and 3 pts.; a dilated one will often retain as much as double this quantity of water.

The administration of a bismuth meal followed by X-ray examination shows the depressed outline of the greater curvature of the stomach.

Treatment.—Lavage in these cases brings great relief. The only cure is by an operation which removes the obstruction—pyloroplasty or gastroenterostomy.

In children a condition closely allied to this, *congenital hypertrophic stenosis of the pylorus*, is not uncommon. The cause of it is yet unknown, the pathological condition is stricture of the pylorus, due either to enormous overgrowth of its muscular fibers (Fig. 66), or to spasm of the muscular coats. It is of interest to know that no example of this condition has been found in the fœtus.

The symptoms usually commence about the third week after birth and it is of first-rate importance to discover, before it is too late, whether the condition belongs to the spastic or hyperplastic group (Koplik), because the first variety may be cured by medical treatment, while in the second, operation is necessary.

Symptoms and Signs.—The child, apparently well-nourished and healthy at birth, commences to have eructations, then vomits increasingly often, and rapidly emaciates. In spite of growing emaciation it continues for long to be vivacious and hungry. A striking characteristic is that the vomited matter is ejected with great force, sometimes as far as 3 to 4 ft. and contains no bile. The bowels are constipated, an unusual sign in infants suffering from ordinary gastrointestinal disturbances.

On inspection, distention of the epigastrium and marked peristalsis in the stomach may be seen and, in the hyperplastic cases, a definite sausage shaped pyloric tumor can always be felt, hardening from time to time.[1]

Treatment.—If a definite tumor is present, operation is the best course. If not, a trial of careful feeding, small doses of opium, and regular daily lavage of the stomach should be fairly carried out. Should these not be quickly successful in arresting the wasting, gastroenterostomy should be performed.

[1] Case report relative to the palpability of the tumor in congenital hypertrophic stenosis of the pyloris. Infant, having manifested the usual symptoms of an hypertrophy of the pylorus but without a palpable tumor and, furthermore, deeply jaundiced, came to autopsy. A tumor the size of a hickory nut was found tucked away under the liver and pressing against the common bile duct; the tumor itself was markedly bile stained. In this way were the jaundice and unpalpability of the pyloric tumor explained.

Acute Dilatation of the Stomach ("*gastromesenteric ileus*").—Following no obvious disease, occurring in the course of an acute illness, such as pneumonia, after the application of a spinal plaster jacket, and, of greatest surgical interest, consequent on an operation, especially an abdominal one, the patient may, without warning and in a short time, be reduced to a perilous state and die from acute dilatation of the stomach. So frequent and important is this condition after abdominal operations that one of my rules is always to suspect it in patients not doing well. Extreme thirst, nausea and depression are the first symptoms, while the first signs are quickening of the pulse, vomiting of dark, foul, brownish green fluid, either frequently in mouthfuls or at longer intervals in quantity, and epigastric distention. If not relieved, the epigastric distention increases, the pulse becomes quicker and feeble, respiration is interfered with, vomiting is performed without force and gives no relief, the case looks like one of advanced general peritonitis, for which it is frequently mistaken, and the patient soon dies from heart failure, craving for drinks till the end. Post-mortem examination shows the abdomen to be filled by the hugely distended stomach and nothing else to account for death. Numerous mechanical explanations, the one most accepted being obstruction by pressure of the superior mesenteric artery on the duodenum, have been offered as causes of the condition, but attendance in the post-mortem room soon dispels any belief in their reality. All that is ascertainable is that the condition is one of paralytic distention with excessive and perverted secretion.

Treatment.—Early use of the stomach tube is the one and only reliable course to take. A single application of it may then suffice to arrest the illness, but, if not, lavage should be repeated as often as distention recurs. All mouth feeding should be prohibited and saline should be administered by the rectum. The patient's position should be frequently changed, and if sitting up or lying on one or other side does not quickly bring relief, the prone position, lying on the belly, should be tried. It is unlikely that the disorder will resist these measures if they are adopted early, so that recovery or death may depend upon a correct diagnosis.

Hour-glass Stomach.—Until Moynihan[1] pointed out the rarity of congenital hour-glass contraction of the stomach, this was believed to be the ordinary type. It is now known to be so rare as to be negligible.

[1] Edin. Med. Jour., June, 1902.

The acquired condition is usually due to contraction from chronic ulceration (Fig. 60); rarely it is the result of perigastric adhesions or of cancer. The orifices of communication between the different chambers into which the stomach is divided by scarring may be narrow enough to give rise to the symptoms of cardiac or pyloric stenosis according to their position. It is important to remember, when operating, that more than one contraction can occur, and that the stomach may be composed of several different compartments; also that, in these cases, there is frequently some stenosis of the pylorus in addition to the hour-glass deformity.

Symptoms and Signs.—In the early stages the symptoms and signs are those of chronic ulceration, and the usual victims of hour-glass contraction are those females who have suffered from their early youth with "indigestion" and have the bodily formation peculiar to visceral ptosis. At a later stage the symptoms and signs may be those of dilatation of the stomach with ulcer, but there are certain specific signs which suggest a diagnosis of hour-glass stomach. They are:

1. In washing out the stomach, fluid introduced is not all returned, a portion of it seeming to disappear.

2. When the stomach has been washed apparently clean, a sudden gush of putrid fluid from another pouch may appear.

3. After emptying the stomach as far as possible by siphonage, succussion from a second full loculus may still be obtainable.

4. On filling the stomach, the left loculus may be seen to distend and then spontaneously, or aided by pressure, the right one, leaving the left empty.

5. When the cavities contain both fluid and gas, gurgling may be felt or heard over the region of constriction, as the contents pass from one sac into the other.

6. X-rays after bismuth meal show a permanent constriction, but this must not be confounded with the temporary contraction due to normal peristalsis.

Treatment.—Operation is necessary in these cases. In all stomach operations it is essential to make a complete examination of the *whole* stomach as the first step and the need of it is nowhere so evident as in these cases.

I have been in the habit of doing for hour glass three types of operation:

1. If the contraction is moderate, by making a long incision through

the posterior portion of the contracted area and anastomosing the jejunum (posterior gastroenterostomy) with this.

2. With pronounced stricture, first dividing this longitudinally through the anterior wall of the stomach and suturing the incision transversely (gastroplasty), then performing posterior gastroenterostomy.

3. When the stricture is specially narrow, by a long longitudinal incision through the center of it and spreading the opening transversely, form a new posterior wall with the spread out hour glass in the center of it, then make a new anterior wall by joining the remaining cut surfaces—this to be followed by posterior gastroenterostomy.

The results of these operations, immediate and remote, have been excellent. Gastroplasty, in many forms, alone, or excision of the ulcer or the ulcer-bearing area alone, has, in my hands, been followed sooner or later by recurrence of the symptoms which only a secondary gastroenterostomy has relieved. I now recommend excision only on cancer cases.

In very ill patients a preliminary jejunostomy may save a life which would be lost from a more complete operation.

Hernia of the Stomach.[1]—The stomach may herniate through an opening in the diaphragm (W. B. Coley) into the pleura, the opening resulting either from a congenital defect or from a trauma. It has also as a rarity been found in an inguinal, femoral, ventral and umbilical hernia. The diagnosis is seldom made until strangulation has occurred, but mistakes would be rarer if the possibilities were more often remembered and modern methods (bismuth and X-ray) employed.

Volvulus of the Stomach.—The three conditions essential to the occurrence of volvulus, viz., rounded shape, space to turn in, and the presence of a pedicle, are so rarely met with in connection with the stomach that few cases have been recorded. It is of interest to note that three of those recorded occurred in the stomach herniated into the pleura,[2] when these conditions are all observed. The remainder appear to have developed only when gastroptosis was present.

Symptoms.—As in all twists the commencement is sudden and the ensuing strangulation causes, as it does everywhere else, the urgent general symptoms associated with shock. Inability to vomit or to bring up wind has been noted, and the signs, when palpation was possible, have been those of a tense cyst in the left upper abdomen, tympanitic on percussion, and filled with gas, which could not be pressed out.

[1] Keen's Surgery, Vol. IV.
[2] Knaggs, Lancet, Aug. 6, 1906.

Treatment.—Death is inevitable unless the condition is quickly remedied, and this can be done only by operation. After the twist is undone measures should be taken to prevent its recurrence.

Diverticula and Allied Conditions of the Stomach and Duodenum.—Diverticula, mostly of congenital origin, have been, though rarely, met with at the pyloric end of the stomach. The conditions described as diverticula at the cardiac end are really sacculi[1], *i.e.*, hernia of the inner coats, and are acquired. The same occur in the pyloric portion. More examples have been reported of diverticulum and accessory pancreas, alone or associated. The sacculi occur in stomachs the walls of which are weakened by disease.

Congenital diverticula also occur, though they are rare, in the duodenum, and, as in the case of the stomach, may be associated with accessory pancreas. Sacculi are not infrequently found on the inner wall near the termination of the common bile duct, especially in old people with visceroptosis.

No pathological changes have as yet been described as associated with these conditions, but it is certain that the dangerous inflammations which occur in the vermiform appendix and in sacculi of the colon will sooner or later be reported as occurring in these connected with the stomach and duodenum.

Neurasthenia, Etc.—No single viscus responds so quickly to disorders of the general health as the stomach; its functions are readily disturbed by reflex and emotional causes, it is apt to show marked idiosyncrasies with regard to food, and the neurotic temperament predisposes it to frequent disturbances. It is, consequently, futile and dangerous to think of it purely surgically. A rule I like to observe is that consultation with a specially skilled physician should be held in at least all but straightforward cases, before operation is decided upon. A mistake in diagnosis may be unavoidable; it may be necessary to open the abdomen to discover what is wrong, but it is inexcusable that so many operations should have been performed for the gastric and intestinal crises and disturbances arising from locomotor ataxia, cerebral tumors, arteriosclerosis, chronic nephritis, diabetes and neurasthenia, operations which, given proper care and skill in diagnosis, were avoidable.

A present tendency to assign all errors of gastric and duodenal diagnosis to vagaries in the behavior of the appendix, and remove it, whether diseased or not, to cure indigestion, requires consideration.

[1] Glasgow Med. Journal, Vol. XLIX, p. 17.

There can be no doubt that disease of the vermiform appendix can cause symptoms chiefly referable to the stomach, but careful consideration and examination seldom fail to lead to a correct conclusion as to the source of mischief in these cases, and the evidence of gross disease in the appendix is apparent to all. Experience has taught me that removal of the appendix, in cases of doubtful diagnosis, more often does harm than good, because nervous patients, finding their symptoms no better after an operation, are apt to imagine that their condition is even more serious than they previously thought. In cases of gastroptosis and visceroptosis, many operations have been performed and much credit claimed for them, but I have seldom found patients as enthusiastic as their surgeons about the results.

It is important to realize that not every pain or disturbance has at present a recognizable organic basis; that, if it has, it is not always curable by operation; and that an operation, though surgically successful, may be a most serious addition to the burden that some of these unfortunates of the world have to bear.

Operations on the Stomach.—The most generally usef ul operation on the stomach at the present time is gastroenterostomy. Though it is far removed, by its interference with the anatomy and physiology of important viscera, from the ideal of what the best operation should be, it may be accepted that experience has proved it to be worthy of a high place. In the vast majority of cases of gastric and duodenal ulcers healing occurs after it, the general health of the patients, for several years at least, has appeared to be entirely satisfactory, and no other known stomach operation holds out equal promise of success. Not only does it conduce to the healing of existing ulcers, but there is also no doubt that it aids in the prevention of fresh ones. It does so in two ways: (1) by neutralization of the acid gastric juice from the passage of the bile and pancreatic secretion into the stomach; and (2) by counteracting the effects of motor insufficiency in preventing attacks of dilatation of the stomach with food retention and increase of the intravisceral tension. The jejunum may be united to the stomach either anteriorly or posteriorly, but as the posterior operation causes less anatomical disturbance, it is so much the better. Guided by the unequalled experience and results of Moynihan and Mayo, I now, following their lead, make the opening into the jejunum as near to its commencement as conveniently possible. The greatest authorities advocate the use of clamps in performing the operation, and they offer many advantages. The operation is made easier by them, there is

not the same chance of gross septic contamination from escape of the stomach and intestinal contents, and there is no interference from bleed-

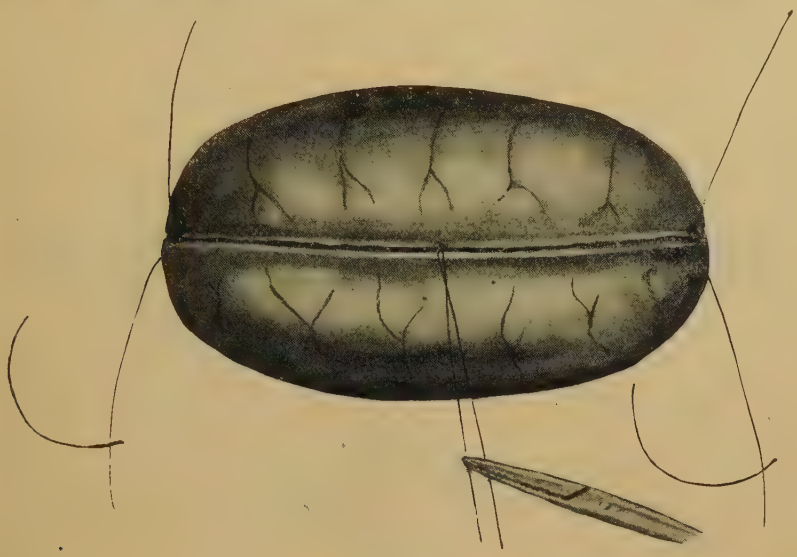

Fig. 67.

ing so long as the clamps remain in position. There is, however, a danger of internal hemorrhage after the operation has been completed,

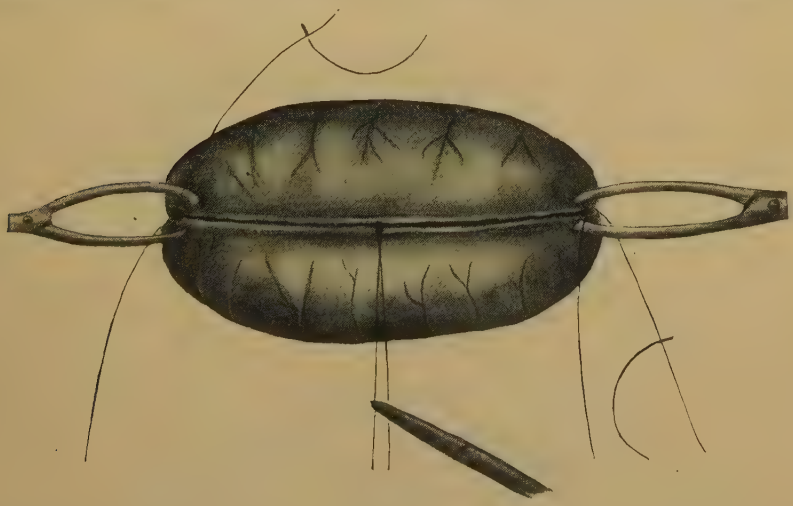

Fig. 68.

and though this may be a negligible risk in the hands of experts, it has so often occurred to my knowledge that notwithstanding the

most powerful advocacy to the contrary, I feel safer in doing the operation without clamps and tying each spouting vessel separately before completing the operation. My results have encouraged me in this

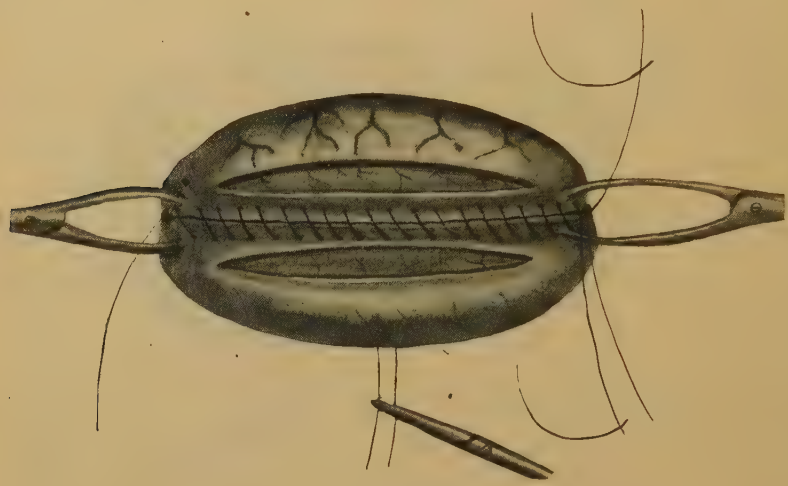

Fig. 69.

course because I have made the operation easy, none of my cases has died of septic peritonitis, none of them has bled from the suture lines

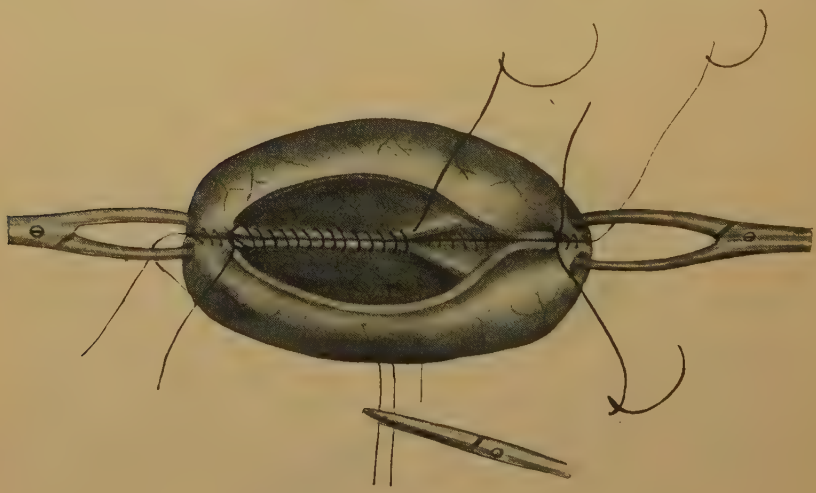

Fig. 70.

after operation, and of the last 88 cases on which I have operated for gastric duodenal ulcer and its complications, including hemorrhage and perforation, there has been only one death, and that occurred from

hemorrhage a fortnight after operation, in the case of an elderly man with multiple ulcers in his stomach and duodenum, one of which had perforated a large blood-vessel.

FIG. 71.

The steps of the operation I do can be readily understood from the accompanying figures (Figs. 67–72).

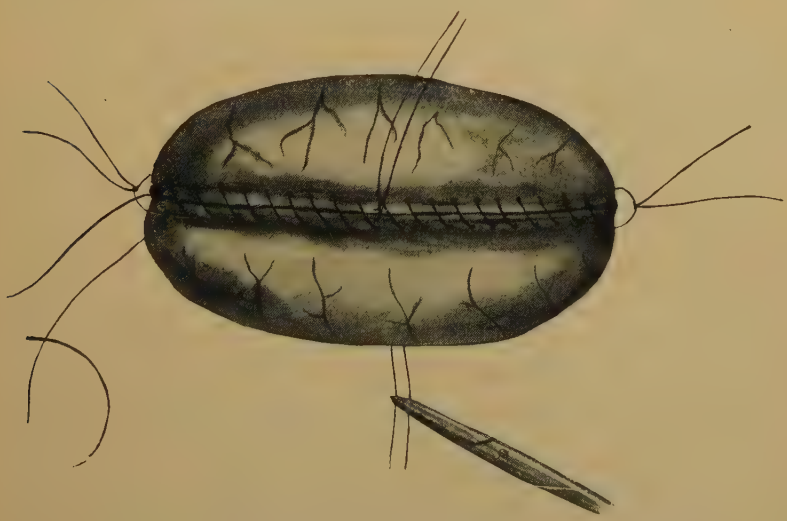

FIG. 72.

The after-results of this operation in my clinic have been carefully followed for more than 10 years. They prove that the chief

cause of failure is the choice of unsuitable cases, especially those of an early date where no ulcer could be found, where nervous symptoms predominated, and on which gastroenterostomy was performed when it was thought to be a radical cure for every gastric trouble.

Excluding these, 90 per cent. of our cases of chronic gastric and duodenal ulcers are entirely well at the end of two years, and the remainder have obtained more or less relief. Our experience accords with that of others in showing that the most brilliant results follow in cases where there has been, in addition to chronic ulceration, mechanical obstruction. That is what surgeons would expect.

It is generally admitted that gastric ulcers affecting the lesser curvature do not give such good results, and excision has been recommended for them by the greatest authorities, for two reasons: The first is their imperfect recovery after gastroenterostomy, and the second, that some of them are already cancerous at the time of operation. It is difficult to reject the strong evidence brought forward in favor of these views, but my own experience does not confirm them. I have found that, though more time and more care in the after-treatment are required in these cases, they ultimately get quite well without excision.[1] I believe also that the limited excision recommended is inadequate if the case be cancerous.

Gastroenterostomy seldom fails in duodenal ulcer cases, though it is best to occlude the pylorus, in addition, when there is hemorrhage, and perhaps to infold the ulcer lest it should perforate.

Complications after Gastroenterostomy.—Hemorrhage has been the cause of many deaths. So far as I know it occurs from the operation site only when clamps have been used, but it may result from erosion of a vessel by ulceration. If it occurs in serious quantity, the only reliable treatment is to reopen the operation wound, incise the anterior wall of the stomach and find the bleeding point.

Vicious Circle Vomiting.—Some hours or days after the operation the patient commences to vomit dark fluid, containing bile and pancreatic juice, and later intestinal contents, and, if unrelieved, dies. I have had the opportunity of examining a number of these cases in the post-mortem room. In some it is clear that the condition has been due to mechanical obstruction from faulty operative technique, in the majority no mechanical explanation is discovered. It is 20 years[2] since I published my opinion, and the reasons for it, that vicious circle vomiting depended more upon loss of the contractile power of the stomach-

[1] See also Sherren (Lancet, July 13, 1912) for confirmation of this view.
[2] B. M. J., 1893, p. 1149.

wall than upon any other factor, and this is still my belief. In many cases, what is now called dilatation of the stomach is found to be the cause. This knowledge is of great practical importance because early lavage of the stomach rarely fails to arrest this serious complication. Should it fail, after a fair trial, the abdomen must be reopened and an anastomosis made between the afferent and efferent jejunum.

Gastrojejunal and Jejunal Ulcers.—The site of the anastomosis may develop chronic ulceration if satisfactory healing does not occur after the operation. This may produce the same symptoms as the original ulcer and may, by cicatrization, close the new orifice and so defeat the object of the operation. The chief means of preventing it are to make good apposition of the mucous surfaces, to use absorbable sutures, and to do the posterior in preference to the anterior operation.

Single or multiple ulcers may develop in the jejunum in the neighborhood of the anastomosis. They are of the same nature as and run a similar course to ordinary gastric and duodenal ulcers, and their pathology is the same. They were more common when the anterior was the operation of choice and have been diagnosed by forming an inflammatory lump, adherent to the abdominal wall, or by perforating. The treatment for both varieties is excision.

Pyloroplasty.—In the early days of stomach surgery, a considerable number of patients were seen with enormously dilated stomachs, due to cicatricial contraction of the pylorus—the result of long-standing ulceration. Like the enormous bladder stones, herniæ, ovarian and fibroid tumors of older days, these have all been cured or have died, and their places are no longer filled. The most remarkable surgical results I have ever seen followed the operation of pyloroplasty on these patients.[1] The operation was as simple as it was efficacious, and consisted in enlarging the pyloric orifice by a longitudinal cut into the stomach and duodenum, and suturing this transversely. Though gastroenterostomy is of more general application, pyloroplasty, in suitable cases, is the better operation, and either the simple method described, or Finney's modification of it, will, in the future, become the operation of election in certain cases, when the indications for it have been better defined.

Excision of Simple Ulcer.—Various types of operation have been performed, *e.g.*, excision of the ulcer only, excision with an area of surrounding healthy mucous membrane, or excision of the whole ulcer-bearing area of the stomach, *i.e.*, the pyloric end (Rodman). The objection to all of them is that, unless gastroenterostomy is performed as well,

[1] After-results of Pyloroplasty, G. Grey Turner, Surgery, Gynecology and Obstetrics, June, 1912.

the cause of the ulceration is not influenced and recurrence is to be expected. With the exception of that involving pylorectomy if cancer is already present, and this has been advanced as an argument in favor of excision, the operation suggested is totally inadequate. Infolding of the ulcer[1] is less serious and as efficacious as excision, and should be the operation of choice when complications demand anything but gastroenterostomy.

Gastroplasty.—I have already indicated the conditions and type of hour glass requiring this operation. It should be combined with gastroenterostomy.

Gastrostomy, i.e., opening the stomach, is chiefly done for the removal of foreign bodies. A longitudinal or transverse incision may be made as convenient.

Gastrotomy.—The indications for this operation are chiefly malignant strictures of the œsophagus or of the cardiac orifice of the stomach. Occasionally it must be done as a preliminary in the treatment of simple stricture. In malignant cases the operation should be postponed until the patient cannot swallow sufficient to maintain strength and weight, and only those anxious to live and still hungry should be operated upon. An operation which is only likely to increase the discomforts of the inevitable end is worse than useless. The operation which has given me most satisfaction is known as the Kader Senn, on the inverted ink-pot principle, and for several years I have when introducing the catheter pushed it on into the duodenum and left it there for 10 days.

Gastrectomy.—The operation of total gastrectomy has been performed with success for cancer of the stomach, but it is rarely indicated, mostly impracticable, and could only be successful when access to the stomach was made easy by unnatural anatomical conformation or by ptosis of the organ.

The partial operation has been frequently done for cancer and with increasing success. I have already, under cancer of the stomach, indicated the method of performing it (Fig. 65). The same operation is applicable to cases of chronic ulcer with fibromatosis and for tubercle of the pylorus.

SMALL INTESTINE

Infections Including Ulcers.—The majority of infections of the small bowel are of medical interest only, but their complications may bring them under surgical notice.

[1] Mitchell, Trans. Roy. Acad. of Med., Ireland, 1901, p. 141.

Diphtheritic and croupous enteritis chiefly occur as secondary processes in such infections as pneumonia, pyæmia and typhoid fever, and are mainly of pathological interest.

"Phlegmonous" enteritis is rare as a primary condition, but not infrequently occurs secondary to intestinal obstruction. The wall of the infected gut is thickened, sodden and infiltrated with pus. The symptoms produced are those of intestinal obstruction or acute peritonitis, and the only satisfactory treatment is to excise the affected gut.

Ulcers of the Small Intestine.—Excluding duodenal and jejunal ulcers, which have already been dealt with in considering gastric ulceration, the chief ulcers met with in the intestine are (1) typhoid, (2) tuberculous, and (3) stercoral.

Typhoid Ulceration.—Peyer's patches, particularly in the lower end of the ileum, become acutely inflamed in the course of typhoid fever. The follicles are at first swollen so as to project prominently into the lumen of the bowel. The inflammation increases, reaching its height from the eighth to the tenth day. The usual terminations of inflammation here, as everywhere, are (1) resolution, (2) fibrosis, (3) partial destruction, and (4) total destruction of the inflamed patch.

When destruction occurs, the depth to which the necrosis extends varies. But when it involves the peritoneal coat, perforation follows. In the ordinary case, after separation of sloughs, an ulcer without surrounding infiltration is formed, usually exposing the muscularis mucosæ, and situated opposite the mesentery. The overlying peritoneal surface shows no tubercles. Healing of these ulcers is usually so perfect that no scar is visible and no stricture is produced.

The chief interest of typhoid ulcers arises from the complications due to their extension, viz., hemorrhage and perforation.

Hemorrhage is less common than perforation, 1 to 3 or 4. It results from separation of sloughs, occurs toward the end of the second week, and as a rule no definite bleeding vessel is demonstrable. When the hemorrhage is serious, in addition to the ordinary signs of bleeding, the previously high temperature drops to subnormal.

Perforation accounts for one-third of the deaths from typhoid fever, occurs commonly in the third week of the disease, affects chiefly the ileum, particularly its lower end, and is of great surgical importance, because lives can and ought to be saved by early operation.

The symptoms and signs produced are those common to perforations of the hollow viscera, modified by the conditions to which the

patient has already been reduced by the fever. There is a sudden seizure of severe, stabbing, deadly pain, followed by general signs of shock, by local tenderness and marked rigidity of the abdomen, and later the symptoms and signs of septic peritonitis develop.

The treatment of perforation here is the same as for like happenings in the stomach and duodenum, viz., to open the abdomen without delay, remembering where the perforation is likely to be found, closing the perforation and dealing with the peritoneal cavity as may be required.

Tuberculous Ulceration.—Intestinal tubercle may be primary, mostly seen in children, or secondary, as in adults, and due to disease in the lungs. In either case the lymph tissue of the solitary glands and Peyer's patches is chiefly affected, and when the tuberculous focus breaks down a tuberculous ulcer results. In the ileum the predominating type of ulcer is ovoid and in the long axis of the gut; in the jejunum it is round or transversely oval, encircling the intestine by following its blood-vessels. The peritoneum over the ulcer is frequently covered by discrete miliary tubercles or thickened by tuberculous infection of its lymphatics. These ulcers may bleed or perforate or heal.

Hemorrhage of large amount is rare and seldom fatal, but in small amounts it is probably more common than is suspected.

Perforation is a not uncommon event, but general peritonitis as a consequence of it is a rare accident. The usual form of peritonitis resulting is one localized by adhesions and developing an abscess. The abscess may find its way into another viscus or to the surface, pointing often at the umbilicus or forming a bimucous or fæcal fistula. The treatment of these fistulæ is one of the difficult problems of surgery, but the deplorable condition the patients are in often makes it necessary for them to face, and for the surgeon to accept, any risk. No tinkering operations have any chance of success. The only hopeful method is wide excision of the diseased bowel with the fistula, followed by intestinal anastomosis, and this operation has been followed by immediate and remote success in a steadily increasing percentage of cases.

Healing of the ulcers may be followed by stricture of the intestine, due to scar tissue encircling it, and such strictures are apt to be multiple, a point not to be forgotten if operation is required.

Tuberculous Tumors.—In the intestine, tubercle may also be found in the form of a *tumor*—simulating malignant disease. It is chiefly met with in the ileocæcal neighborhood and is described as hyperplastic tuberculous tumor.

Stercoral Ulcers.—Intestinal stasis, either functional or organic, produces stagnation and putrefaction of the intestinal contents; inflammation followed by ulceration may result, and the ulceration threatens life, by hemorrhage and perforation, or by more general interference with health and nutrition. The most acute varieties of ulcer are seen in the distended intestine above, or involved in a mechanical obstruction, and they resemble closely the so-called acute ulcers of the stomach and duodenum by showing as a small rounded gangrenous patch on that portion of the intestine furthest removed from the main vascular supply, viz., the convexity opposite the mesentery. Many neglected obstruction cases have died of peritonitis following perforation of these ulcers.

Tumors of the Small Intestine.—Growths in the small intestine are much rarer than colon tumors.

The simple varieties are adenoma, fibroma, fibromyoma, lipoma. The adenomata spring from the mucous membrane and are frequently multiple; the others usually arise in the submucous coat and are generally single.

All of them have a special proclivity for developing toward the lumen of the gut to form polypi. A natural cure can follow rupture of the pedicle and their extrusion from the intestinal canal. Rarely they cause hemorrhage from ulceration but the usual signal of their presence is an attack of intestinal obstruction. This is generally the result of intussusception started by the polypus, but rarely may be due to mechanical blocking of the canal by the growth. In either case the treatment is operation. Either the tumor can be removed after enterotomy or preferably the involved intestine with the tumor can be excised.

Sarcoma.—With the exception of the rectum, sarcoma occurs much more frequently in the small than in the large bowel. It appears at all ages but is most frequent between thirty and forty, and, though all types have been found, lymphosarcoma is most common. It usually commences in the submucous lymph follicles, extends in the long axis of the gut, invades the muscular coat, causing paralytic distention, and may ulcerate, bleed and perforate. Sarcoma rarely begins in or invades the peritoneal coats, usually it infiltrates the submucous and muscular coats only, and occasionally it develops toward the lumen forming a polypoid tumor.

Libman[1] offers a classification of which a summary may be taken as a guide to the symptomatology.

[1] Keen's Surgery.

1. Latent cases. Tumors discovered at autopsy.
2. The presence of a tumor or distention is discovered.
3. Intestinal obstruction or perforation is produced.
4. Conditions resembling peritoneal tuberculosis result.
5. Jaundice the first symptom.
6. Resembles an ovarian cyst.
7. Like appendicitis.

The only treatment is surgical and though the results of operation are very discouraging, excision offers the only chance.

Carcinoma.—Cancer is quite rare in the small compared with the large bowel. The growth is a columnar-celled carcinoma and the same types are found as in the rest of the alimentary canal.

1. Annular, causing stricture and obstruction.
2. Soft fungating growth, with hard infiltrated base and rapidly disseminating.
3. Crateriform ulcerating growth.
4. Diffuse, involving gut-wall.

Cancer more usually occurs in older patients than sarcoma; it causes more pain, the glands are enlarged, and the tumor formed by cancer is small compared with that of sarcoma. Operation offers the only prospect of relief.

Deformities, Etc.—*Meckel's Diverticulum.*—Normally, the vitello-intestinal duct, which forms a communication between the fœtal intestine and the yolk sac, completely disappears. In 2 per cent. of bodies some reminder of it remains. When wholly unobliterated a tubular canal, opening into the intestine internally and at the umbilicus externally, and forming a fæcal fistula, represents the duct. When wholly obliterated, but retaining its original attachments, a vascular cord is found passing from the intestine to the umbilicus. Its intestinal connection occurs with remarkable frequency within 3 ft. of the ileocæcal opening. Between the extremes there are great variations in size and structure. The distal end of it often separates, leaving a diverticulum or a vascular cord. This may either be free or form new attachments, especially to the mesentery.

If the remnant left is tubular it may cause serious symptoms either from inflammation in it or from intestinal obstruction, and if only a cord remains, intestinal obstruction can be produced.

Inflammation of the diverticulum clinically and pathologically resembles appendicitis so closely that a differential diagnosis is not often possible, and the prognosis of both is the same. In both, a mild

and transient inflammation terminates in resolution, a less mild and more continued, in fibrosis. The more serious terminations are (1) partial destruction (ulceration or sloughing) with peritonitis, either localized to abscess or diffuse, and (2) total destruction (gangrene) with perforation and septic peritonitis to follow. In both vermiform appendix and Meckel's diverticula stercoroliths, or, more rarely, foreign bodies, may be found.

Intestinal obstruction is a not infrequent result of a Meckel's diverticulum, and may be produced in several ways.

1. The diverticulum or band may strangulate a loop of gut which has passed under it.

2. The diverticulum or band may form a loop and snare the gut.

3. A free diverticulum may knot itself round the bowel.

4. The diverticulum may invert into the bowel and, like a polypus, cause intussusception.

5. It may produce a secondary volvulus.[1]

6. It may kink the gut at its point of attachment.

7. It may be associated with stricture of the intestine at its point of origin.

The symptoms and signs produced are those of shock and obstruction when the bowel is strangulated; if not, the three cardinal symptoms of obstruction, viz., spasmodic pains, inability to pass flatus, and visible, audible, or palpable peristalsis make a diagnosis definite.

The treatment of the diverticulum is removal in the same fashion as the vermiform appendix is excised, and that of the complications, according to surgical rules.

Sacculi.—These are rare in the small compared with the large intestine, but in both are due to hernial protrusions of the inner coat through vascular openings in the outer. In the small intestine they are found at the mesenteric border and tend to burrow between the peritoneal layers. Their chief importance arises from the fact that inflammation in them may demand surgical intervention.

Stricture of the Small Intestine.—*Congenital strictures* are found chiefly in the lower end of the ileum, next most commonly in the first or second part of the duodenum, and most rarely in the jejunum. They may be tight enough to cause death by mechanical obstruction, or so moderate as to produce no symptoms. It is of interest as suggesting an explanation to note that in the same position as strictures are formed, two portions of gut have been discovered to terminate as

[1] Introduction to Surgery, Rutherford Morison.

blind ends, or two blind ends have been joined by a fibrous cord, or again, there has been a membranous diaphragm obstructing the lumen, or all degrees of stricture.

Acquired Stricture.—Ulceration and cicatricial contraction are the cause of simple acquired stricture of the small intestine. The ordinary causes are septic inflammation, most common in the duodenum, and tuberculosis, most frequent in the lower ileum and often multiple.

Less ordinary are the ulcerations following strangulated hernia, the separation of an intussusception, injuries damaging the gut, surgical anastomosis, or the presence of foreign bodies, all of which may be followed by cicatricial stricture.

Malignant stricture has already been considered under cancer of the intestine.

The symptoms produced by stenosis of the small intestine are variable. On account of the fluidity of the contents a marked stricture may produce no symptoms until some particularly bulky and indigestible food causes trouble. The attack is then attributed to "indigestion" and is frequently relieved by an aperient. From this to acute obstruction, all grades of disability may be observed. Vomiting, from the first, is likely to be a prominent symptom. Distention occurs late, but when it does occur the abdominal prominence is central, resembling that produced by an ovarian cyst.

Treatment.—Short-circuiting by lateral anastomosis is the most generally useful measure.

Peritoneal Bands and Adhesions.—Peritonitis arising from any cause may produce adhesions either local or general. The most dangerous of these are local, small, thin bands which may ensnare a loop of intestine, strangulating and obstructing it as a piece of string would.

Next to these come broader though localized adhesions, which may cause obstruction from kinking or secondary volvulus.

In either case symptoms of acute obstruction follow and, unless early operation is performed, death is almost inevitable. Except in these definite conditions there is room for doubt.

Much mischief has been and still is attributed to the presence of adhesions, the kinks produced by them, and their proper treatment, but little is really known. It is, however, certain that operations for their removal are more likely to increase than to diminish them and that ordinary surgeons had better let them alone.

Gastroptosis and Enteroptosis.—A certain type of person of delicate build, with stooping, sloping shoulders, a long narrow chest, a straight spine, and a protuberant lower abdomen, comprising females chiefly, is specially predisposed to the disturbances produced by laxity of attachment and displacement of the viscera. In this class occur the great majority of victims of "intestinal stasis," symptoms and signs of which are described so graphically by Lane. The treatment he suggests, based upon his well-known views, is exclusion of the colon by ileo-sigmoidostomy, or excision of it if this fails. Other surgeons advocate fixation of the proptosed viscera by a variety of operative measures more or less ingenious, and from each of which satisfactory results have been reported.

My belief is that the "benefits" of operation in these patients is illusory, that the majority are made worse by operation, and that the best treatment for them is a suitable supporting bandage, attention to their health, exercises under skilled supervision, and conduct guided by a frank recognition of their limitations.

SECTION IV

THE VERMIFORM APPENDIX

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Anatomy.—It is most important to bear in mind the anatomica relation of the vermiform appendix to the surrounding structures in connection with this chapter because the proper treatment of the diseased vermiform appendix is based very largely upon this relation and cannot be fairly considered unless one bears it in mind at all times. The relation is sufficiently constant to be depended upon, although there are almost innumerable aberrant relations which must constantly be remembered and which will be considered as the chapter progresses.

The mechanical isolation of the appendix vermiformis in the peritoneal cavity should first be borne in mind. By its attachment to the lower end of the cæcum it is protected by a perfect wall above and is drawn slightly inward by its mesenteriolum toward the lower side of the ileum. Posteriorly, anteriorly and externally it is protected by the solid walls that bound the peritoneal cavity. Below, it rests upon the iliacus muscle and may be in contact with the right ovary and Fallopian tube in the female and with the upper portion of the bladder, or it may project downward into the cul-de-sac of Douglas. To the inner side it is in contact with coils of the small intestines.

It is well to bear in mind that this organ is consequently limited by relatively firm structures in every direction except to the inner side and that this limitation is still further increased by the contraction of the internal and external oblique abdominal muscles and by the rectus abdominis muscle and that there is still a further increase of this condition of isolation from the fact that the omentum places itself about the appendix as soon as the latter shows symptoms of inflammation.

All of these conditions can be utilized greatly to the benefit of the patient in the treatment of diseases of the vermiform appendix and should constantly be remembered although one may forget most of the facts concerning the anatomy of the vermiform appendix without being seriously handicapped in the treatment of these cases.

Blood Supply.—From the standpoint of treatment the blood supply is the most important anatomical element because its interruption as a result of thrombosis is by far the most common cause of serious disease of this organ.

The main blood supply of the appendix comes from the posterior ileocæcal artery through its appendicular branches. These are usually arranged in a fan shape between the layers of the mesoappendix. The more regular we find the arrangement of these vessels and the more directly the branch extending along the edge of the mesoappendix passes to the tip of the appendix the more likely is the organ to remain free from inflammatory disease. On the other hand the shorter the mesentery and the less perfect the arrangement of the blood-vessels, the more likely are we to find inflammatory disturbances of the appendix.

In most instances the anterior ileocæcal artery supplies at least some small branches to the base of the appendix and occasionally a considerable portion of the blood supply comes from this source.

In the female, Clado's ligament in some instances contains a small artery which communicates with the appendicular arteries in the mesenteriolum.

In cases in which there has been thrombosis of the appendicular arteries the omentum sometimes surrounds the organ, forms permanent adhesions, and gives a new blood supply from its own vessels which may continue to provide the greater part of the circulatory system of the appendix after the inflammatory processes have subsided.

The venous system of the appendix consists of a submucous and a subperitoneal set of veins. The submucous veins pass out into the mesoappendix, from there to the posterior cœcal vein and thence through the ileocolic into the portal system.

The subperitoneal veins empty into the cœcal veins to some extent but most of the branches follow the course taken by the branches originating in the submucous tissues.

The Lymphatics of the Appendix.—The amount of lymphatic tissue is relatively very large in the appendix. The sinuses pass out from the basilar lymph sinuses in the mucous layer along with the veins, through the gaps in the muscles, encountering usually one or more appendicular lymph-glands in the mesenteriolum on their way to the chain of lymph-glands lying in the ileocolic angle along the inner border of the ascending colon. Some of the lymphatics from the appendix extend along each of the arteries and veins described above, making a very intricate network.

Nerve Supply.—A thorough comprehension of the nerve supply of the appendix is extremely important especially from the standpoint of diagnosing conditions of the appendix as well as from the point of appreciating many of the secondary conditions such as duodenal irritation, pyloric spasm, intestinal stasis and other disturbances.

The branches of the superior mesenteric plexus of the sympathetic nerve which accompany the ileocolic artery send filaments to the appendix both to the peritoneal and muscular coats and also to the blood-vessels of the mucous membrane. Many twigs from the plexus go to the ileum which may account for the pain throughout the area occupied by this gut when there is an inflammatory disturbance of the appendix.

The irritation of the nerves supplying the appendix is likely to produce secondary symptoms as a result of an irritation of the cells in the segment of the spinal cord from which these nerves are derived. This segment is the same as that from which the eleventh and twelfth dorsal and the first and second lumbar nerves arise.

This fact accounts for the pain at McBurney's point, the rigidity of the abdominal muscles and the pain located in various other portions supplied by these nerves which are so frequently encountered during acute attacks of appendicitis.

In the same manner the contraction of a portion of various abdominal muscles can be explained. The circumscribed character of these contractions frequently give rise to an error on the part of the diagnostician who may mistake the swelling produced by this muscular contraction for an accumulation of pus within the peritoneal cavity, a condition which will be further discussed in connection with the consideration of diagnostic symptoms. These secondary effects due to irritation of the nerves located in and near the appendix are so varied and so important that we cannot speak of them too often even though one may object to repetitions.

Histology of the Appendix.—The structures comprising the vermiform appendix from within out, are the mucous membrane, the submucous connective-tissue layer, the circular muscle layer, the longitudinal muscle and the peritoneum. The mucous membrane is characterized by cylindrical glands lined with columnar epithelium and by relatively large areas of lymphoid tissue. The cylindrical glands present an admirable arrangement for the secretion of mucous so long as there exists free drainage into the cæcum but when the communication between the cæcum and the appendix is obstructed it seems as

though infection through these glands must be relatively easy. The large areas of lymphoid tissue make the absorption of septic material from the lumen of the obstructed appendix easy, which undoubtedly accounts for the frequency with which this condition is followed by a chill and high temperature. The submucous connective tissue is very loose and permits of a considerable amount of dilatation of the mucous lining.

The circular is the thickest layer of muscle, being nearly as thick as the corresponding layer in the cæcum. The strength of this layer undoubtedly explains the severe pain which is caused by its spasmodic contraction upon some foreign body, although the continuous pain is due to pressure upon the nerve filaments caused by the œdema accompanying acute inflammation of the appendix.

The longitudinal muscle layer is usually of much less thickness than the circular muscle. Both layers show gaps through which the blood- and lymph-vessels pass to the mucous coat.

The peritoneal coat is composed of connective tissue covered with a single layer of endothelial cells.

The free communication between the mucous membrane and the peritoneum along the spaces occupied by the blood- and lymph-vessels and through the stomata between the endothelial cells undoubtedly accounts for the rapidity with which an infection of the mucous lining is carried to the surface of the organ and thence to the peritoneum in the immediate vicinity. This arrangement appears, at first glance, to predispose to dangerous peritonitis, but when we consider that the absorption of toxins brings about effective protection from the omentum, the cæcum and the other neighboring structures, the provision seems most excellent and efficient.

DEFORMITIES AND BANDS

The deformities of the vermiform appendix can be classified as congenital and acquired although it is at times difficult to determine absolutely to which of these two classes an individual case may belong.

Congenital Deformities.—Congenital deformities consist especially of variations in the size and form of the organ. It may be unusually long, reaching in very unusual cases the length of 30 cm. and not infrequently the length of 12 to 18 cm. An appendix of unusual length is most likely to be relatively too long for its mesenteriolum and this condition frequently results in a twisting upon itself of

the entire organ giving it a corkscrew appearance, or it may be curled upon itself after the fashion of a snail or in any one of a number of forms. It may be found twisted about a pendulous cæcum or it may reach to the bottom of the pelvis and in the presence of inflammatory conditions its length may favor its adhesion to distant intra-abdominal structures. I have seen the distal end of the appendix attached to every intra-abdominal organ with the exception of the left kidney and the spleen.

On the other hand the appendix may be congenitally short. There is apparently no limit to the deformity in this direction although I have personally never encountered an entirely rudimentary appendix in practice yet this condition has been frequently described in the surgical literature.

A funnel-shaped appendix is not uncommon. It consists of a more or less uniform narrowing of the end of the colon to a point, so that it is difficult or impossible to determine where the cæcum ends and the appendix begins. This form is not encountered surgically nearly so often as one which may be considered as its direct opposite because its narrowest portion is attached to the cæcum while its distal portion is club-shaped. The funnel-shaped appendix is rarely obstructed because its contents can escape most easily into the cæcum while the club-shaped appendix presents precisely the opposite condition. Undoubtedly in the majority of cases, however, the club-shaped appendix is not congenital but is the result of a dilatation of the distal end due to an obstruction to the passage of its contents into the cæcum resulting from a narrowing of the cæcal end of the lumen. This narrowing is caused by cicatricial contraction subsequent to an inflammatory process and may have resulted from single or recurrent attacks. There are also many deformities relating to the lumen of the appendix. There seems to be some uniformity, however, in that the long appendix is more likely to be unusually narrow in its lumen while the opposite seems to be true of the short appendix.

Deformities Due to Inflammation.—The form of the appendix may be changed almost infinitely as a result of more or less severe inflammation of the organ and the surrounding structures. The deformity produced depends upon the amount of inflammatory destruction in the appendix as well as in its surroundings, the structures actually destroyed being replaced by connective tissue. Adhesions formed during the progress of inflammation may contract later on and draw what is left of the appendix into almost any portion of the peritoneal cavity.

I have seen the distal end of the vermiform appendix adherent to

every intra-abdominal organ except the left kidney and the spleen and I have seen the lumen at its distal end communicate with the cœcum, the right Fallopian tube and the bladder and have removed several appendices which, judging from their position, had perforated into the ileum.

A not uncommon deformity is produced by gangrene destroying the proximal part of the appendix, the distal part remaining nearly normal in structure. On recovery, the gangrenous portion is replaced by fibrous tissue. Thus a hornet-like condition is found, the remnants of the appendix constituting the belly of the hornet and the scar tissue the waist uniting it to the cæcum.

Often when it seems as though one were dealing with an appendix which is abnormally short, further investigation reveals the fact that it belongs to the group of cases just described.

It would be possible to enumerate almost any number of deformities due to inflammatory causes but nothing would be accomplished by this. It will suffice to state that in all of these cases there is more or less evidence of the primary inflammation in the form of adhesions, bands, simple thickenings, indurations or constrictions, all due to the deposit and contraction of connective tissue.

Connective-tissue Bands.—Apparently there are bands in the region of the appendix of congenital origin but these do not seem to be of much importance to the surgeon in the consideration of the vermiform appendix with the exception that when they are encountered during the surgical treatment of appendicitis it is proper to deal with them surgically at the same time. Of these the Lane's kink and Jackson's veil are the most important. Late investigations seem to favor the idea that they are of congenital origin although this has not as yet been generally accepted.

Bands directly connected with the appendix may be of almost unlimited variety. It may be said in a general way that unless they give rise to some form of constriction or obstruction they need not be considered from the standpoint of the surgeon and that when considered and treated, unless the treatment results in the elimination of this one element, the patient will not be benefited.

Ordinarily these bands are encountered incidentally and disposed of in a routine manner and it is difficult to determine whether there has been any definite benefit. On the other hand, they may give rise to various degrees of obstruction by engaging loops, usually of the small intestines. In a few instances a band originating from the

appendix passing across the ileum at the point of its entrance into the cæcum has been the exciting cause of an ileocæcal intussusception. In several cases the end of the appendix has been carried around the ileum at the same point, becoming attached at its distal end by means of a small band of adhesions and has been the exciting cause of an intussusception. In strangulation of the intestine the constricting band may be entirely composed of connective tissue or part of it may consist of the appendix.

Adhesive bands originating from an inflamed appendix have been the exciting cause of volvulus of the small intestine or of twisting of the pedicle of an ovarian cyst. In a number of cases I have encountered these bands constricting the cæcum or the sigmoid flexure of the colon and giving rise to subacute intestinal obstruction or to intestinal stasis with its toxic results. In a few instances the same result has been observed in cases in which bands of adhesions drew the transverse colon down toward the origin of the adhesion in the region of the appendix.

In cases in which appendiceal adhesions involve the omentum, the greater curvature of the stomach is at times drawn down sufficiently to produces a considerable degree of pyloric obstruction.

In many cases with a history of severe acute appendicitis, I have found adhesions tying down the gall-bladder, although there are rarely definite bands of adhesions. Under such circumstances the gall-bladder frequently contains stones and it is difficult to determine whether the adhesions caused sacculation and partial immobilization of the gall-bladder with resultant formation of gall-stones or whether the gall-stones were formed first and the adhesions resulted from the infection accompanying the formation of the gall-stones.

There can be no doubt but that adhesions have often been blamed wrongly for conditions which are the result of other causes.

Appendicitis Obliterans.—Among the acquired deformities of the vermiform appendix is a condition in which a greater or smaller portion of the lumen has been obliterated. This may have resulted from the destruction of the mucous membrane by gangrene or it may have been caused by destructive ulceration and subsequent cicatrization. At times portions of the appendix have escaped this destructive process and the obliteration is only partial. The portion most affected is commonly the proximal, but it may be the distal end. If the proximal end is obliterated, the distal part is left lined with mucous membrane but isolated from the lumen of the cæcum. In isolated cases several

segments of the lumen may be left as cavities separated from each other by areas of cicatricial tissue. The mucous membrane of the segregated parts of the appendix may continue to secrete mucus and this may become a culture medium for pathogenic microörganisms so that it may give rise to recurrent attacks of appendicitis. Again only a relatively short portion of the proximal end of the appendix may suffer from a destruction of the mucous membrane and when this has been replaced by connective tissue completely obstructing the lumen, there still remains a large area of mucous membrane from which a sufficient amount of mucus and serum may be secreted to produce a cyst of considerable size. I have encountered one of these cysts 12 cm. long and 17 cm. in its greatest circumference and much larger ones have been described by other surgeons.

Diverticulitis.—There may be dilatation of the tubular glands in the appendix producing a condition of diverticulitis. These diverticula are distended with thick viscid mucus unless an acute infection has resulted in an accumulation of pus. The condition is much less common than the cystic dilatation of the appendix which, however, is also quite rare. There may also exist a single diverticulum of the appendix but this condition is still rarer than those just described.

INFECTIONS

Because of its continuity with the lumen of the cæcum which is constantly loaded with both saprophytic and pathogenic microörganisms the lumen of the vermiform appendix usually contains the same flora. The great amount of lymphoid tissue present undoubtedly serves as a protection against infection and the secretion from the tubular glands must serve to carry the infected material into the cæcum with the help of the circular and longitudinal muscle fibers, but this can be true only as long as there is a free communication between appendix and cæcum or, what is really more important, a free passage from the appendix to the cæcum. Fortunately, nature has provided a slight barrier against the passage of cæcal contents into the appendix by means of a fold of mucous membrane at the mouth of the appendix which acts like a valve and by the fact that the entrance of the appendix extends obliquely through the walls of the cæcum. This valve-like arrangement is, however, not sufficiently exact in its function to protect the lumen against the entrance of much infectious material. In many instances objects of considerable size have found their way into the

lumen of the appendix. In my own experience the following objects have been encountered: pinworms; shot; pins; bristles from a toothbrush; wood (apparently a part of a toothpick); a grapeseed; a tooth; a piece of bone; a gall-stone; a piece of oyster shell; small seeds (probably from figs) and of course a larger number of fæcal concretions, the latter undoubtedly having been formed in the lumen of the partly occluded appendix.

Foreign bodies may be so harmless that they are frequently found incidentally in cases operated on for other conditions and in which the appendix is being examined as a routine practice; especially in this true if the objects are smooth in character. When the foreign bodies are sharp-pointed or rough, they usually give rise to ulceration and later to perforation. Fortunately, the perforation is usually preceded by adhesions which prevent an infection of the general peritoneal cavity.

It seems that normally the cæcum and the appendix should contain the colon bacillus in great numbers. Whether these microörganisms aid in the normal physiological processes which go forward in the cæcum, as has been so enthusiastically insisted upon by McEwen and others, or whether they are so constantly taken with the food and have the power of withstanding the destructive action of the physiological secretions and digestive processes between the mouth and the cæcum, is still open to discussion. The fact remains that human beings in perfect health constantly harbor these guests in the cæcum and in the appendix and so long as there is no obstruction to the progress of the material containing these bacilli toward the rectal exit they do not have any pathological significance. This is entirely changed the moment that drainage from the appendix into the cæcum is obstructed. Drainage may be obstructed by the impaction of an enterolith in the cæcal end of the appendix, by œdema or even mere congestion exaggerating the obstruction already caused by the presence of cicatricial narrowing of the mouth of the appendix.

However the obstruction is produced, the result is identical. There is at once an enormous increase in the number of colon bacilli, the tension in the lumen of the appendix increases the secretion from the glands of Lieberkuhn, the cells in the solitary follicles become helpless and the products of the septic process are carried in every direction through the lymph vessels. Here as elsewhere when this toxic material is produced in quantities too large to be cared for by the lymph nodes in the mesenteriolum and in the ileocolic angle, the symptoms of severe septic infection become apparent in the form of a

chill followed by elevation of temperature, high leucocytosis and headache.

Fortunately, for the patient the early transmission of the septic material to the surface of this organ brings about its physiological isolation because the cæcum at once becomes distended with gas producing a pneumatic cofferdam above; the ileocæcal valve closes and produces a similar protecting structure in the form of distended loops of the ileum to the inner side. In the meantime our good friend the omentum has gathered its delicate folds about the organ so that it is not only isolated but immobilized. In many hundreds of cases operated on within 48 hours after commencement of the attack of acute appendicitis I have been able to demonstrate this condition by carefully opening the peritoneal cavity and inspecting the organ *in situ*. I have been able to demonstrate the beautifully efficient isolation of the infected appendix between the cæcum, ileum and abdominal wall in an enormous number of patients who came under treatment too late for an early operation. In these patients the physiologic protection was favored by inhibiting peristalsis. Peristalsis is best prevented by washing out the stomach and by the absolute prohibition of any cathartics or the swallowing of any food no matter whether liquid or solid. So thoroughly does nature accomplish this isolation that the infectious material is quite as completely separated from the general peritoneal cavity as it would be had it originated entirely outside this cavity.

Fortunately at the present time even the layman has learned to recognize appendicitis at so early a stage that all of the infectious material can be and usually is removed while it is still confined to the lumen of the appendix and before any microörganisms have made serious progress in their development outside this organ. In early cases the removal of the appendix, of course, at once disposes of the entire infection. The peritoneum is quite capable of destroying a moderate amount of infectious material which may have been carried beyond the tissues removed by the operation.

As the disease progresses there may have been poured out into the peritoneal cavity innumerable leucocytes so that the peritoneal fluid is found on operation to be cloudy and viscid to the touch. This effusion must be distinguished from that of septic or purulent peritonitis because it is as absolutely favorable in prognosis as the latter is unfavorable.

The multiplication of microörganisms within the obstructed appendix may rapidly increase the intra-appendicular pressure. This increased pressure acting on the walls of the appendix may by itself

or in conjunction with œdema of the walls, cause occlusion of the capillaries and subsequent gangrene. The nutrition of the appendix may also be shut off by thrombosis due to absorption of infection from an ulcerated point usually at the site of an enterolith.

It is here that the importance of the distribution of the blood-vessels in the mesenteriolum becomes apparent. When the blood-vessels supply the appendix uniformly, the appendix rarely becomes gangrenous throughout. On the other hand, whenever the distal end of the appendix is not well supplied because the mesenteriolum does not reach to it, the distal portion is likely to become gangrenous. If an enterolith is present, there frequently results a circumscribed area of necrosis with perforation instead of gangrene. If in the meantime a condition of rest and immobilization has not been established by prohibiting the ingestion of food and cathartics, the appendix may still be free in the peritoneal cavity instead of being isolated and thus the perforation or gangrene will be followed by an infection of the peritoneal cavity. The severity of this infection will depend primarily upon the kind and virulence of the infectious material expelled into the peritoneal cavity from the appendix and upon the means which may be employed for the limitation of the infection by the method of treatment which may be instituted.

Character of Infection.—Although the colon bacillus is practically always present in acute appendicitis, it is seldom found in pure culture but usually mixed with at least one other pathogenic microörganism, most commonly the staphylococcus albus. Not infrequently, one or more of the other common varieties of pathogenic microörganisms, are also present. Of these the most common are the staphylococcus aureus, the streptococcus pyogenes, the pneumococcus, the influenza bacillus and in a few cases the typhoid bacillus has been found. As appendicitis has been repeatedly observed following dysentery, measles, scarlet fever, mumps and small-pox as well as chicken-pox it seems likely that the infection causing these diseases may be the exciting cause.

The histories of most cases of acute appendicitis seem to prove that the incidence of the inflammation is favored by the overloading of the alimentary canal with microörganisms as a result of such diseases as typhoid, influenza etc., etc.

The fact that acute attacks frequently follow the ingestion of too much or of specially indigestible food, makes it seem likely that the

consequent increase of microörganisms in the intestines at such times may be a causative factor.

I have made the following experiment on a large number of patients who had recovered from an acute attack of appendicitis.

They were placed on a relatively aseptic liquid or semi-liquid diet consisting of sterilized milk, soups, mush, soft boiled eggs, purees, mashed vegetables, fruit juices and cooked fruits. Recurrence of the appendicitis occurred only in those who abandoned this diet. Of course, this diet was not only free from infective material but from substances which would be likely to irritate the mucous lining of the alimentary canal, but it seems likely that the absence of pathogenic microörganisms must have been of primary importance.

Tuberculosis and actinomycosis have given rise to appendicitis. In some of these cases an acute exacerbation has been caused by secondary infection with pus-producing microörganisms coming from the lumen of the appendix. The secondary infection reaches some portion of the swelling caused by the primary infection and which has broken down; it invades the surrounding tissues after forming an abscess in this area of low resistance. In many instances the primary infection may not have given rise to marked symptoms while the secondary pus infection is usually very violent in character and consequently the diagnosis of the primary trouble is likely to be overlooked altogether or it may be made accidentally or incidentally during the operation for a supposed perforative appendicitis with more or less severe septic peritonitis or with the formation of a circumscribed abscess whose position and size will depend upon the character of the primary infection and the extent of the secondary condition at the time of the operation.

Classification.—Deaver's classification gives a fair idea of the degree of infection.

Cases of acute appendicitis are classified as (1) catarrhal; (2) interstitial; (3) ulcerative (a) non-perforative, (b) perforative; and (4) gangrenous. Cases of chronic appendicitis are classified as (1) catarrhal; (2) interstitial; (3) obliterating.

It must be borne in mind that the extent and virulence of the infection in any individual case at the time the specimen is obtained for examination is no indication of the condition at any previous time neither can it be any indication of what the probable condition of the same appendix would have been at a future time had it not been removed when it was. My personal experience in surgery goes back to the time

when the first few operations were performed for the relief of acute appendicitis and with the almost absolute lack of experience at that time our imagination invariably pictured a most dire tragedy from the appendix which seemed severely infected and for its unfortunate owner had it been permitted to remain in the peritoneal cavity only a little longer. It seemed impossible that any organ so severely diseased could ever regain the semblance of its former self after having undergone so severe a degree of inflammatory destruction.

Then as our experience increased we came to observe perfectly parallel cases in one of which we removed a severely, in fact apparently a hopelessly, inflamed appendix while in another case with precisely the same symptoms we were not permitted to operate and the patient recovered. Later on many cases of the second group came to operation because of the chronic disturbances following the acute attack and to our amazement we would find a condition which convinced us that our primary diagnosis must have been wrong. Then we came to observe a considerable number of cases in which the inflammatory condition of the appendix was still more severe; in many of these there was an actual perforation with the expulsion of a large fæcal concretion, with abscess formation and with the patient in so serious a condition that the removal of the appendix was not attempted. The wound was drained, frequently a fæcal fistula persisted for some time; later the patient came to operation for relief of a post-operative ventral hernia. During this operation the appendix was located and again to our amazement the organ showed little of the severe inflammatory condition which was present during the attack preceding the primary operation.

During all of these years we have had an opportunity to observe the living pathology of the appendix in all of its forms of advancement and retrogression and repair in every imaginable stage of acute and chronic inflammation.

Combining these pathological findings with a careful study of the histories and the clinical findings we ought to be in a position, by applying this experience to the individual case, to state with a fair degree of certainty precisely the degree and character of infection to be encountered in case the organ were to be removed at that time.

Strange to say, it seems impossible to do this unless the surgeon has actually observed a considerable number of these cases personally and even then he occasionally meets with surprises.

Some 15 years ago while traveling abroad we were astonished to find that some of the very best diagnosticians systematically over-

looked or diagnosed wrongly cases of acute appendicitis just as we had done 10 years earlier. They were thoroughly familiar with the literature but they had not personally seen the living pathology in a sufficient number of cases in which they had previously taken the clinical history and made the physical examination. These cases were perfectly clear to us with our experience and a few years later became equally clear to these most excellent clinicians.

The object of this statement is to impress the young surgeon with the fact that in the diagnosis and treatment of appendicitis, as in many or in fact most other surgical conditions, it is of the greatest importance for him to have become thoroughly familiar practically with this disease in hospital services under the direction of a surgeon of wide experience and not to depend upon descriptions except to confirm this practical knowledge.

COMPLICATIONS

The most common complications of appendicitis are those which depend upon the fact that some of the infectious material has been carried from the appendix itself to other structures in the body. We dwell most emphatically upon the carriage of infection because it is connected with the greatest amount of danger to the life of the patient and his future health if he has been so fortunate as to have only one of the less serious complications.

In the second place the complications should be emphasized because, with fair experience, a reasonable amount of knowledge, some intelligence and a little attention on the part of the physician treating the patient from the beginning, the complications can be eliminated almost completely. There is a time in every case of appendicitis when all of the infectious material is located in the appendix and can be safely removed from the body without any danger of coming into contact with or being carried to any other tissue in the body. It is simply necessary to make an early diagnosis and to remove the appendix at once before infection has become disseminated.

The areas nearest the infected portion of the appendix most commonly suffer from the disseminated infection and in cases in which peristalsis has been inhibited soon after the beginning of the appendiceal infection (by permitting the patient to take no food of any kind and no cathartics by mouth) the infection is almost invariably confined to these areas; especially is this true if any food or mucus which may be in the stomach or any intestinal contents which may have regurgitated into

the stomach have been carefully evacuated by the use of gastric avage .

Usually the space below the cæcum becomes infected and an abscess is formed, bounded above by the cæcum and appendix, to the inner side by the omentum, anteriorly and externally by the abdominal wall and posteriorly by the peritoneum covering the psoas and iliacus muscles.

Next in frequency we find the infection behind the cæcum involving the connective tissue extending between the ascending colon and the posterior muscles. Next most commonly we find the infection extending downward into the pelvis being shut off from the upper portion of the peritoneal cavity by the cæcum, sigmoid, and omentum. Aside from these areas any area may be involved provided the infected appendix occupies an abnormal position. For many years while the pernicious practice of treating all abnormal intra-abdominal conditions by the use of cathartics was generally in use, we frequently encountered areas of infection in several circumscribed intra-abdominal areas because the resulting peristalsis carried the infectious material from the region of the appendix to these points, but now since this practice has virtually been confined to the most ignorant portion of the laity multiple areas of infection are but rarely met with.

Diffuse Peritonitis.—The most serious complication of appendicitis, which was also most commonly due to a dissemination of infectious material from the appendix by means of peristalsis which was caused by the administration of food or cathartics or both by mouth, has fortunately disappeared to a very marked extent. This is due to the fact that in a vast majority of cases the diagnosis is made before the infectious material has passed beyond the appendix and the latter is removed during this period and in the second place because in cases in which the infection has passed beyond the appendix when the patient comes under the physician's care it is prevented from being carried further by the inhibition of peristalsis described above.

In many of the larger hospitals cases of extensive peritonitis due to appendicitis were admitted almost daily only a few years ago while today weeks and months may pass without the admission of a single case belonging to this class.

Metastatic Abscesses.—In the same manner there has been an enormous decrease in thrombophlebitis of the mesenteric veins due to the same cause and consequently the metastatic infections which were not uncommon during the reign of terror caused by the use of the

cathartics have almost disappeared as complications or sequelæ of acute appendicitis.

Metastatic lesions were formerly found most commonly in the lung or pleura, in the liver or in the subphrenic space. The parotid gland was a favorite location for the formation of secondary abscesses. Since using chewing gum to stimulate salivary secretion we have encountered parotitis very rarely.

Abscesses may give rise to further infections usually by invading the connective tissue spaces behind the peritoneum so that the same patient may have successively several abscesses, any one of which may involve the abdominal wall or follow the sheath of a blood-vessel so that we have encountered them almost everywhere on the external surface. Occasionally they invade the ischiorectal fossa resulting in perirectal abscesses or fistulæ or they may invade the bladder or the vagina or may empty into any one of the hollow viscera.

In place of causing metastatic infections, thrombosis of the mesenteric veins may become so extensive as to produce gangrene of the intestine. This may be confined to a small area of the lower end of the cæcum, ultimately giving rise to a fæcal fistula. Next to the cæcum, the ileum is most likely to become gangrenous because of its proximity to the primary seat of infection.

Intestinal Obstruction.—It is important to distinguish between true intestinal obstruction and the physiological obstruction to the passage of gas and fæces which occurs soon after the beginning of a severe attack of acute appendicitis and which is undoubtedly an attempt of nature to confine the infectious material to a circumscribed area in or near the diseased organ. The sphincter ani muscles prevent the evacuation of gas, thus changing the sigmoid and the cæcum into a physiological cofferdam. The ileocæcal valve becomes contracted and by preventing the passage of gas into the cæcum fixes and immobilizes the small intestine. The ensuing nausea prevents the ingestion of food by the mouth.

All of these conditions combine to produce a physiological obstruction to the passage of gas and fæces. As soon as the pathological condition of the appendix has subsided, all of these conditions relax and gas and fæces again pass. For years it was supposed that the local inflammatory condition improved because of the re-establishing of peristaltic action and upon this misconception the murderous practice of treating by the free use of cathartics was based. It is true that in many cases in which the patient did not suffer from acute appendicitis

but from enteritis or constipation possibly complicated by a mild catarrhal appendicitis the results were satisfactory. This class of patients, however, would have recovered under any or no form of treatment but where there was serious disease present, a disturbance of the physiological protection resulted frequently in the most serious complications. It may be well to insist upon this point at this place that an obstruction which is not due to strangulation need not give rise to any anxiety for the safety of the patient so long as nothing is given by mouth to increase the pressure from above and so long as gastric lavage is applied whenever symptoms of nausea or vomiting appear. In this manner the condition, known as intestinal paralysis, so much feared a few years ago, has been almost entirely eliminated.

True intestinal obstruction occurs very rarely as a complication of appendicitis. It is commonly a result of strangulation by means of a band of adhesions and is usually a post-operative complication rather than a complication of the appendicitis itself.

Occasionally the resulting peritonitis in acute appendicitis causes such severe adhesions between the loops of the small intestines or between these and any of the other intra-abdominal organs or the abdominal wall that a more or less severe intestinal obstruction may result and may become absolute. In most instances, however, gastric lavage and complete abstinence from food, cathartics and even water by mouth will result in sufficient loosening of the obstructing adhesions for nature to re-establish a fairly normal passage. In the meantime water and liquid nourishment must of course be supplied by rectum, preferably by means of Murphy's method of proctoclysis. Occasionally it will become necessary to relieve the acute condition of intestinal obstruction by means of enterostomy or enteroanastomosis.

One of our patients in whom we performed the latter operation between two loops of the ileum suffered six years later from a second intestinal obstruction caused by an intussusception of the proximal segment of the ileum through the anastomotic opening in the distal segment.

It is most important to bear in mind that only a very small proportion of cases of apparent intestinal obstruction in patients suffering from acute appendicitis, or after operations for the relief of acute appendicitis, are really due to mechanical obstruction of the intestine and that in almost all the obstruction will subside if gastric lavage and complete abstinence from food and cathartics by mouth are employed.

Cholecystitis.—So large a proportion of patients suffering from cholecystitis are suffering from subacute appendicitis or have appendices showing that they have in the past been seriously diseased that it seems proper to classify this as one of the complications of appendicitis. Whether both conditions are due to the same infection from the alimentary canal or whether the infection travels through the portal system from the appendix to the gall-bladder does not seem entirely clear but there seems to be no doubt that there must be a definite relation between the two conditions.

Gastric and Duodenal Disturbances.—In the same manner we find many patients suffering from pyloric spasm and some from gastric or duodenal ulcer who give a very definite history of appendicitis preceding the attack of gastric or duodenal disease. It has been suggested that through the common nerve-supply the pyloric spasm may be produced in order to give physiological protection to the diseased appendix.

Mucous Colitis.—This complication may be so severe as to mask the symptoms of appendicitis for a time. It is sometimes difficult to determine whether the infection is primarily located in the colon and has reached the appendix by extension or whether the opposite is true.

Diseases of the Ovaries and Fallopian Tubes.—The proximity of these organs, the direct connection of the blood- and lymph-supply through Clado's ligament in many cases and the facility with which infectious material from the appendix can drain into the pelvis makes this complication not uncommon. In two instances I have encountered a perforated appendix that ruptured directly into the right Fallopian tube. In several instances I have treated cases in which a tubal infection caused an adhesion of the vermiform appendix to the right broad ligament and later the patient suffered from an acute appendicitis probably due to a constriction caused by the malposition resulting from the inflammatory adhesion.

In many cases of ovarian cyst there is a distinct history of acute appendicitis early in life which may have infected the peritoneum covering the ovary causing the formation of connective tissue which later resulted in conditions producing the cyst. In many cases I have found a retroverted adherent uterus with prolapsed ovaries and tubes all tied down in the cul-de-sac of Douglas as a result of a peritonitis secondary to an acute appendicitis. Again we find loops of intestines adherent to ovaries or tubes as a result of an appendiceal peritonitis.

Undoubtedly many women are sterile because of one or more of the

above conditions and consequently early operation in young girls and women is especially indicated in order to avoid such complications.

It is very common to find women in whom the menstrual function was perfectly normal and painless previous to an attack of appendicitis and in whom suffering from dysmemorrhea was afterward constant. In other instances patients have a mild recurrence of a subacute appendicitis with more or less regularity during each menstrual period caused apparently by the temporary congestion which is present during this time.

In many, sterility can be directly traced to an attack of appendicitis.

Pregnancy.—Pregnancy is a common complication of appendicitis especially in young married women. It is important to bear in mind the fact that the removal of the appendix before the end of the fourth month is strongly indicated because of the danger of an acute attack being set up by the vigorous motions of the child *in utero*. It is also to be expected that the same cause will greatly increase the pain in the wound during the process of healing if the operation is postponed until later.

The operation can be performed without danger to the patient or the child if done quickly and if all unnecessary manipulations are avoided. It would, of course, be wrong to subject a pregnant woman to a long operation but this is quite unnecessary.

The traumatism accompanying labor may act as the exciting cause of acute appendicitis. I have personally operated upon two cases of acute gangrenous appendicitis which came on during labor and I have seen a number of cases which developed shortly after delivery and were consequently mistaken for puerperal conditions. There is usually, however, a history pointing to previous attacks. The attack usually begins with the typical symptom of pain in the region of the umbilicus which later becomes located opposite McBurney's point but the other symptoms are so nearly alike in puerperal peritonitis and acute appendicitis that it is difficult to distinguish between them. It has been claimed that a high leucocytosis indicates that the case is one of appendicitis but it does not seem likely that this can be depended upon. Whenever there is any doubt it is undoubtedly best to place the patient in bed with the head of the bed elevated 15 or 20 in., prohibit all food and cathartics by mouth, make gastric lavage if there is nausea or vomiting and supply liquid and food by means of very slow protoclysis.

Extra-uterine Pregnancy.—Except as a coincident condition extra-uterine pregnancy could of course not occur as a complication of acute

appendicitis. It has occurred once in my personal experience. There can, however, be no doubt but that conditions of the Fallopian tubes favoring the production of extra-uterine pregnancy are frequently the direct result of the peritoneal infection resulting from acute appendicitis. In a considerable proportion of cases suffering from ectopic gestation, pathological changes present in the appendix indicate that at some time in the past the patient has suffered from acute appendicitis with more or less marked peritonitis and it is usually possible by careful questioning to elicit a definite history confirming the correctness of this view.

Typhoid Fever.—Many cases of appendicitis have been traced directly to infection during an attack of typhoid fever. Until very recently the practice of obtaining the supply of drinking water from sources into which human excreta were drained was so generally in vogue that all of the older surgeons must have encountered cases in which appendicitis and typhoid fever were present at the same time in patients under treatment for the relief of one or the other of these conditions. I have personally observed an interesting case of acute appendicitis in which the patient drank large quantities of typhoid infected water to quench the thirst caused by fever resulting from the appendicitis. After the infected appendix was removed the patient started in with a typical course of typhoid fever from which she recovered normally.

Hernia.—Strangulated hernia complicated with acute appendicitis is not very uncommon. Whether the appendicitis is due in all of these cases to the strangulation or whether the appendix may have been located in the hernial sac and the acute inflammation developed as it would have, had the organ been in its normal position, it is difficult to state but undoubtedly the former condition is more usual. The condition has always been in right inguinal herniæ in my personal cases and this must undoubtedly be the most common location but cases have been reported as occurring in various forms of hernia.

I once found a non-strangulated perforated appendix in a right inguinal hernia in a patient in whom the right testicle had not fully descended. It was not possible to determine any relation between these conditions and it seemed as though the inflamed condition of the appendix was quite independent of its location in the hernia.

Neoplasms.—Aside from the granulomata, due to infection with the ray fungus or the tubercle bacillus and the very rare occurrence of gummata the most common form of neoplasm is carcinoma arising from the mucous membrane of the appendix and developing precisely as do similar

tumors from the mucous membrane of the large and small intestine. The free communication with the surrounding structures through the lymph channels makes this disease especially dangerous because metastasis is so easy and consequently common. Several cases in which the tumor was removed at a very early stage under the diagnosis of simple appendicitis have been permanently cured but when the condition is sufficiently advanced to be diagnosed primarily it is usually hopeless notwithstanding very thorough excision.

If the tumor is sufficiently developed to be palpable through the abdominal wall the differential diagnosis between tumor of the appendix and tumor of the cæcum cannot be made but this is of no practical importance because in either case the only possible chance for saving life must come from an extensive excision and no intelligent patient would insist upon having a differential diagnosis made before the abdomen was opened in case a tumor were even suspected.

After the abdomen is opened it is important to make a differential diagnosis between carcinoma and tuberculosis, actinomycosis or inflammatory adhesions. If carcinoma is found, wide excision is indicated. If actinomycosis is the disease present, all abscesses due to secondary infection should be drained while the disease itself should be treated by the administration of 90 gr. of potassium iodide at intervals of eight hours for 12 doses followed by an interval of one week when the treatment should be repeated in order to destroy the fungi which have been developed in the interval from spores. This form of treatment should, of course, be repeated until the swelling has been entirely absorbed. The potassium iodide should be dissolved in half a pint of hot milk and a pint of hot water should be taken directly after taking the remedy in order to insure its rapid absorption because it seems that the result depends upon the rapid absorption of a very large quantity of the medicine and upon its administration at intervals.

In case of tuberculosis the same methods employed in the treatment of intestinal tuberculosis described elsewhere should be employed.

The appearance of tuberculosis and actinomycosis is very similar with the exception that in the former, one practically always finds typical tubercles in other portions of the peritoneum, while this is not the case in actinomycosis.

The mesenteric lymph nodes are involved in tuberculosis to a much greater extent than in actinomycosis. If the swelling is opened one finds the tuberculous tissues containing necrotic areas filled with typical caseous tuberculous material while in actinomycosis one finds

granules from which the typical ray fungi can be shown under the microscope.

Many authors speak of a typical temperature varying from 99°F. to 100°F. or higher in the afternoon and a normal or subnormal temperature in the morning in case of tuberculosis. This, however, is not constant enough to be depended upon. Neither does it seem wise to depend upon a tuberculin test for the purpose of making a differential diagnosis because a very large proportion of patients have old foci of tuberculosis in the apices of the lungs and elsewhere.

Symptoms of Appendicitis.—The symptoms of acute appendicitis have been before us so long that even the laity very commonly make a correct diagnosis.

The first reason for failing to make a correct diagnosis lies in the fact that many practitioners have had little of such clinical bedside training as would have placed them in actual contact with patients while under observation by competent clinicians and in whom the pathological conditions would be subsequently demonstrated during operation. Unless a physician has had such training he may readily misread some very typical symptoms.

The second reason for failure in making an early diagnosis lies in the fact that there are still some physicians who will prescribe for patients suffering from intra-abdominal conditions without having made a physical examination. This is true especially in the treatment of children, and it accounts for the frequency with which appendicitis in children is overlooked until the disease is far advanced.

We should consequently insist upon a careful physical examination in every patient suffering from symptoms of intra-abdominal disease.

Symptoms.—The most important and at the same time the most typical symptoms are pain, tenderness upon pressure, and rigidity of the muscles of the right lower quadrant of the abdominal wall.

The symptoms usually come on in patients who have previously complained more or less of disturbances in their digestion, frequently with constipation or with intermittent diarrhœa. Sometimes they have suffered occasionally from nausea and sometimes they complain of having had slight twinges of pain, especially after eating too much, too rapidly, or too indigestible food.

Pain.—At first the character of the pain is usually paroxysmal and referred to the vicinity of the umbilicus; later it extends toward McBurney's point where it continues until the inflammation subsides or the organ becomes gangrenous.

If peristalsis is inhibited by the use of gastric lavage and prohibition of food and cathartics by mouth, the paroxysms become much less frequent and usually subside entirely in a relatively short time. In the meantime the pain upon pressure may decrease in intensity, but it will not disappear for a considerable time. The rigidity of the muscles overlying the appendix also persists, the muscular contraction often causing a swelling of considerable size which may readily be mistaken by a physician of slight experience for an abscess, especially in cases in which the greater portion of the omentum has gathered about the cæcum and appendix.

Tenderness.—Although the typical location for tenderness is at a point about the middle of a line drawn from the umbilicus to the right anterior-superior spine of the ilium, and which is directly over the usual location of the vermiform appendix, there are so many variations in the location of the appendix that a mistaken diagnosis is frequently made because of the fact that McBurney's point has been so universally accepted as *the* point of tenderness in acute appendicitis.

It is reasonable to make a diagnosis of appendicitis with the organ in an abnormal position when the other symptoms are positive but when the tenderness upon pressure is at some point away from McBurney's point.

Many times the appendix is adherent in an abnormal position. If the inflammation arising in the appendix involves some of the important nerves, like the genito-crural, the anterior crural, or the ilioinguinal nerve the pain may be referred to any point along the distribution of these nerves.

There is frequently an area of cutaneous hyperæsthesia in the right iliac region which increases in sensitiveness with the advancement of the disease and decreases with its improvement. This symptom does not compare in value with the symptoms of tenderness upon deep pressure.

Muscular Rigidity.—It is well to bear in mind that rigidity of the abdominal muscles is an attempt of the muscles to protect the underlying inflamed tissue by establishing physiological rest; hence the location of this rigidity in the vicinity of McBurney's point so long as the infection is confined to this area. Should the infection spread to other portions of the peritoneal cavity the rigidity will also spread. In case of a general infection of the abdominal cavity the entire abdominal wall becomes rigid.

Undoubtedly this rigidity frequently protects the patient against

harmful manipulations from without. In many cases I have observed a marked exacerbation following a thorough, or better a violent, physical examination during which a powerful surgeon exerted much force in an attempt to palpate a diseased appendix through the rigid abdominal walls. If one bears in mind that the recognition of the rigidity is much more indicative of the actual condition of the appendix than anything one can possibly feel through such an abdominal wall, it becomes apparent that violence is strongly contraindicated in the palpation of the abdomen in making a diagnosis of acute appendicitis. It is especially important to bear this fact in mind when several physicians make a physical examination during a consultation. Several years ago it was customary to anæsthetize patients in whom one suspected acute appendicitis for the purpose of making a more thorough examination and a more accurate diagnosis. I recall several instances in which the patient was severely injured by the manipulations which caused infectious material to be forced out of its circumscribed location into the surrounding tissues, and in one instance I witnessed the rupture of a circumscribed abscess into the general peritoneal cavity which ended fatally, although an operation was made at once with careful cleansing of the soiled peritoneum and free drainage.

Violent diagnostic manipulations should be entirely avoided, and in fact after the diagnosis has once been made all manipulations should be forbidden. In case operation is not performed at once, progress can be observed quite as satisfactorily, and with much greater safety to the patient, without any further manipulations.

I have observed severe exacerbation of symptoms many times directly after thorough or violent physical examinations in cases of acute appendicitis which had progressed satisfactorily before the patient had been subjected to the traumatism of this diagnostic massage. The bad effects in these cases have been proportionate to the degree of violence.

It should be borne in mind that the harm done to the patient is in no way compensated by the information obtained, and that the risk to the patient of having infectious material forced out of its circumscribed area into the surrounding tissues is great not only as regards the immediate prognosis but also as regards the development of practically all of the important complications which have already been mentioned.

There is a symptom-complex in young children which should be borne in mind, because it is almost absolutely certain to indicate the presence of a foreign body in an abnormal appendix. I refer to the

symptom of colicky pains regularly referred to the vicinity of the umbilicus in children with erratic appetites and in whom one can elicit discomfort or nausea by making pressure in the region of McBurney's point.

Nausea and Vomiting.—Except in very mild cases nausea is almost always one of the early symptoms and is followed by vomiting unless the condition subsides. If the attack of acute appendicitis comes on shortly after food has been taken, the nausea is usually followed by vomiting of the food which has just been taken; later on the vomitus contains bile and mucus and in severe cases this may be followed by dark grumous, and still later by stercoraceous, material. Stercoraceous vomiting, however, occurs rarely except in cases in which cathartics and food have been taken after the beginning of the attack. It is also still more rare when gastric lavage has been employed directly after the first appearance of nausea.

In many cases hiccough is present either alone or in connection with nausea and vomiting. This symptom seems to be present especially in cases in which the peritoneum is severely irritated by the septic condition and when severe gaseous distention of stomach and intestines is absent.

Apparently nausea and vomiting, and possibly also hiccough, result from an attempt at a physiological protection against disturbance of the inflamed area by the passage of gas through the inflamed ileocæcal valve. The fact that gastric lavage will usually promptly relieve all of these conditions seems to confirm this view. It has been claimed that in the presence of obstruction to the natural passage of intestinal contents from the stomach to the colon the duodenum secretes a very toxic substance. Animal experimentation (especially by Draper) supports this view as does also the favorable change observed in the condition of patients immediately after the removal of the gastric contents by the use of gastric lavage. If no further food and no cathartics are taken by mouth it is rarely necessary to employ gastric lavage more than once, twice or at most three times to cause these symptoms to subside completely and permanently. Hiccough is, however, the most persistent of these three symptoms.

Any one of the above symptoms may be the cause of a form of vicious circle. The presence of localized peritonitis causes nausea, vomiting or hiccough; the muscular contractions accompanying these symptoms in turn cause a certain degree of spreading of the infection and this in turn increases the symptoms. It is plain, consequently, that gastric

lavage should be employed at once as soon as one or the other of these symptoms appears so as to avoid this unfavorable influence upon the progress of the condition.

Constipation.—As indicated above, there seems to be a physiological tendency to place all of the intra-abdominal organs at rest so as to protect and isolate the inflamed area. This fact has often given rise to a diagnosis of intestinal obstruction instead of appendicitis; in fact during the early period of surgical treatment of appendicitis we constantly spoke of intestinal obstruction accompanying it. In very severe cases the obstruction may in fact be due to a septic peritonitis, but this is true of only a relatively small proportion of cases. In the vast majority the condition is undoubtedly due to the physiological action of the intestine and not to a pathological condition of the portion of the canal which actually prevents the passage of intestinal contents.

Pulse.—In the early stages of the attack the pulse is of little or no importance in making a diagnosis. Later on, however, the quality of the pulse is one of the most useful means of determining the severity of the attack.

A strong regular pulse of good volume whose rate is in keeping with the existing temperature usually indicates a favorable prognosis, while a pulse with the opposite characteristics must be looked upon as indicating a very grave condition.

Temperature.—High fever is sometimes but not usually preceded by a chill, which usually indicates that serious damage has occurred to the appendix. It is well to bear in mind the fact that a high temperature means the absorption from some source of a considerable quantity of septic material, but this may have no direct relation to the condition in the appendix itself or to the gravity of the disease or to the prognosis. It is well to search for a reason for the high temperature, provided that in so doing the abdomen in the region of the appendix is not manipulated sufficiently to force septic material from the infected area into surrounding tissues.

The temperature may be high because of involvement of the surrounding peritoneum, or it may be due to the occurrence of any one of the numerous complications that have been mentioned. A pneumonia or an abscess at some distant point or a phlebitis may be the cause of this increase in temperature.

I have never seen a case of acute appendicitis in which a normal temperature has persisted throughout the attack, but it does not seem safe to lay too much weight upon the condition of the temperature

in making either a diagnosis or a prognosis. Aside from the degree of leucocytosis no symptom can be less reliable than the temperature.

Leucocytosis.—In a general way it may be said that a high leucocytosis means that there is absorption of a large amount of septic material or that the patient's physiological resistance to this absorption is great, or it may indicate that both of these conditions are present. A low leucocyte count may indicate directly the opposite of the above.

We have carefully made a differential count in hundreds of cases of acute appendicitis and have come to the conclusion that one constantly encounters most interesting conditions but that it is neither safe nor wise to base the diagnosis, treatment or prognosis upon the blood findings. Although it may happen at times that quite a series of cases show uniform findings, one's theories are sure to be shattered if one continues the observations.

Respiration.—In many cases nature seems to provide protection to the intra-abdominal organs by shallow respiration confined chiefly to the upper portion of the chest. In other cases, in which the stomach and the intestines are severely distended with gas, the respiration is shallow because of lack of space for breathing. In these, respiration may be extremely rapid, especially when in the presence of severe peritonitis.

Since the introduction of Fowler's position and the use of gastric lavage the marked respiratory symptoms are much less common than formerly, because both of these methods relieve the chest of much of the difficulties which formerly interfered with its function.

In fatal cases the respiration is likely to become rapid and difficult, especially when the diffuse peritonitis is accompanied with extreme nervousness. The protective physiological rigidity of the abdominal muscles seems sometimes to spread to the diaphragm and to the muscles of the lower part of the thorax, thus causing such thoracic fixation that respiration becomes specially shallow and almost entirely confined to the upper thorax. After the muscles have become accustomed to their new duties, respiration becomes easier, but close inspection shows that there is still limitation of respiratory motion.

Outside Disturbance.—In severe cases the patient seems to be extremely sensitive to anything which might disturb the rest of his intra-abdominal organs.

Approaching the abdomen with the hand may perceptibly increase the tension of the muscles, even touching the bed may cause the patient to complain. In the early days when many surgeons confounded vio-

lence in examination with thoroughness, I frequently observed these spasmodic contractions of the abdominal muscles in cases which were subjected to this senseless, diagnostic, abdominal massage in a vain attempt at making a diagnosis which can now be made without causing the slightest distress to the patient.

Chronic Appendicitis.—In making a diagnosis of chronic appendicitis, it is especially important to take into consideration the history of the patient.

There may be a distinct history of an acute attack, or the patient may recall only a series of more or less typical symptoms such as the following:

There is practically always more or less digestive disturbance which increases after taking heavy or indigestible food, eating too much or eating while tired from severe physical or mental labor. There may be symptoms of nausea. Constipation is usually marked. The appetite is likely to be erratic. There may be some pain, often colicky, in the region of the umbilicus or in the region of the appendix. There is usually much gaseous distention of the intestines and frequently there is eructation of food. There may be regular intervals of exacerbation varying from a few days to weeks or months. The exacerbations often appear at certain seasons when the patient is given to over-eating, as during the Christmas holidays or during the late summer or autumn in regions in which fruits abound. Several observers have noted exacerbations during periods of the local endemic occurrence of influenza or acute tonsillar infections.

It seems that anything causing a depression in the general condition of the patient is likely to give rise to an exacerbation of the chronic appendicitis, and that by strenuously avoiding all indiscretions in diet, general hygiene, work and worry these exacerbations may be avoided almost entirely, especially if the patient guards against constipation by the use of olive oil or liquid paraffin.

Recurrent Appendicitis.—Everything that has been said about chronic appendicitis can be said with more emphasis about recurrent appendicitis. Authors differ in their estimation of the average percentage of cases suffering from acute appendicitis in which one may expect recurrence, some placing it as low as 20 per cent., others as high as 80 per cent.

The clinical material for observation differs so greatly that it would be possible to obtain a correct percentage only if one could take a large number, say 10,000 infants, and follow the history of each one from

the cradle to the time of the removal of the appendix. The important fact that a large number of patients who have once suffered from an acute appendicitis will have a recurrent attack, unless the appendix is removed, has been thoroughly established, and it does not matter much what the exact percentage may be. The reasonable conclusion must be to prevent such a recurrence, if this can be done with safety to the patient. Fortunately, there is a time in practically ever case of acute appendicitis when this can be done, namely, while the infection is still confined to the appendix itself. It may be well to state here that this is true not only because in this manner the patient will be relieved of grave danger, but also because his recurrent attacks may prevent him from competing successfully with others in the same walk of life. The career of many a primarily successful man has been hopelessly ruined because he was not urged to undergo a perfectly safe operation which would have prevented him from following his regular occupation for a period of one month at the most. The same is true regarding children whose development is prevented to a marked extent by these recurrent attacks which could and should be prevented. In female children undoubtedly the secondary effects such as dysmenorrhœa, sterility, intestinal stasis and all of the consequent neurotic conditions can be avoided by removing the appendix at the very beginning of the first attack or before the occurrence of the first recurrence, should the patient not come under the surgeon's care in time for an early operation.

Too much stress cannot be laid upon the fact that practically all the injuries that come upon human beings as a direct or indirect result of appendicitis, whether acute, chronic or recurrent, are readily and safely avoidable.

Differential Diagnosis.—When it is difficult to make a differential diagnosis between appendicitis and some other condition it may be said, in a general way, that an exploratory operation is indicated. This does not mean that one should fail to make a positive diagnosis in any considerable number of cases, because with care and experience it is almost always possible to do so promptly. In the few instances in which this is impossible a positive differential diagnosis may be made at a glance when the abdomen is opened, without harm resulting other than that temporarily inflicted on the diagnostic conceit of the surgeon. Delay incident to protracted observation and traumatism due to palpation are far more dangerous than is operation. In practice it is always well to keep in mind the following conditions which, in my own clinical experience, have led to erroneous diagnosis: (1) typhoid fever; (2) per-

forating typhoid ulcer; (3) cholecystitis with or without gall-stones; (4) abscess of liver; (5) renal colic; (6) nephritic and perinephritic abscess; (7) movable kidney with or without twisted ureter; (8) gastric ulcer; (9) duodenal ulcer; (10) acute pancreatitis; (11) acute indigestion; (12) intestinal colic; (13) intestinal obstruction; (14) thrombosis of mesenteric vein; (15) perforating ulcer of ascending colon or cæcum; (16) carcinoma of ascending colon or cæcum; (17) tuberculosis of ascending colon or cæcum; (18) tuberculosis of vertebræ with psoas abscess; (19) pyosalpinx; (20) ovarian cyst with twisted pedicle; (21) abscess of ovary; (22) abscess of abdominal wall; (23) incipient inguinal hernia; (24) dysmenorrhœa; (25) inflammation of right spermatic cord; (26) tuberculous peritonitis; (27) lead-poisoning; (28) pleurisy; (29) herpes zoster; and (30) hysteria.

As long as the infection is confined to the appendix the symptoms are usually so clear that it is not likely that one could mistake the condition for any of those mentioned above but after the infection has once gone beyond the appendix, the symptoms are frequently clouded to a marked extent and the patient may not be able to give a very definite history.

1. **Typhoid Fever.**—Since we have the Widal test it is not common to mistake typhoid fever for appendicitis. Reliance on the Widal test may easily lead us to overlook appendicitis especially since so many persons in districts in which typhoid fever is common have been subjected to vaccination against typhoid and in these a positive Widal reaction may be found.

2. **Perforating Typhoid Ulcer.**—If the patient has passed through a typical siege of typhoid fever, a perforation will naturally not be mistaken for an appendicitis but in the so-called cases of walking typhoid fever this is not the case.

It is usually possible to find some basis for a suspicion of typhoid even in these cases but the severe and sudden collapse is more likely to suggest the correct diagnosis than is any other symptom. There is frequently present at this stage of typhoid fever a typical roseolar rash which will suggest this correct diagnosis. A precise differential diagnosis is not of prime importance because immediate operation is always indicated and if a diagnosis of appendicitis has been made it will at once be corrected upon opening the peritoneum. An escape of gas together with the congested condition of the ileum and the relative absence of inflammation in the appendix will at once suggest the presence of a perforation.

It is not wise to depend upon the generally accepted symptom of absence of liver dullness in the diagnosis of typhoid fever perforation.

3. **Cholecystitis.**—In many cases an acute appendicitis and an acute cholecystitis occur in the same patient. When this is the case the entire right rectus abdominis muscle is tense. If only the appendix is involved the lower portion of the muscle is tense while if cholecystitis alone is present it is the upper portion of the muscle which is rigid.

4. **Abscess of the Liver.**—The location of this in the upper portion of the abdominal cavity usually suffices to make differentiation possible.

5. **Renal colic** has very frequently been mistaken for acute appendicitis especially if the stone becomes lodged in one of its favorite points where the ureter crosses the iliacus muscle. The X-ray cannot always be depended upon because fæcal concretions in the appendix sometimes make definite shadows. The fact that there is irritation of the bladder cannot be considered pathognomonic because this is often the case when a gangrenous or suppurating appendix is adherent directly over the ureter. The most dependable symptom of renal calculus is the history of the attack beginning in the region of the kidney and passing down in the direction of the ureter. When the appendix is located behind the cæcum and high up in the dorsal region, the pain may be most marked in this region; but this is very rare. A number of cases have been reported in which renal or ureteral stone and acute gangrenous appendicitis were present at the same time in the same patient. In the former condition there is usually a considerable amount of blood in the urine while in the latter this is very rare although a few red blood corpuscles are often found.

6. **Nephritic and Perinephritic Abscess.**—It is not always possible in cases of long standing, especially if fistulæ have been formed, to determine definitely whether the condition is due to a retrocæcal appendiceal abscess or to a nephritic or perinephritic condition. In either case a posterior incision for drainage is indicated and later on the exact location of the infection can be determined by filling the cavity with bismuth paste through the drainage opening and examining it by means of the X-ray.

7. **Movable Kidney.**—Movable kidney is found most commonly in emaciated women in whom the condition can usually be determined by palpation. There is also usually a very distinct relation between this condition and bladder disturbance. If the ureter becomes twisted, the attack corresponds to a period during which but little urine is being

voided and following the relief from the attack urine is voided in greatly increased quantity.

The muscular rigidity is in a much higher portion of the rectus abdominis muscle than in appendicitis.

8. **Gastric Ulcer.**—The point of tenderness is located much higher. In case of perforation shock is extreme. The muscular rigidity involves both recti muscles. It is not wise to wait for absence of liver dullness before operating.

9. **Perforation of Duodenal Ulcer.**—Perforation of duodenal ulcer has occurred simultaneously with acute appendicitis but this must, however, be looked upon as a coincidence. The symptoms correspond very closely with those of perforating gastric ulcer with the exception that the muscular rigidity is usually confined to the upper end of the right rectus and to the oblique abdominal muscles on the right side. Moreover, there is usually a distinct history of chronic duodenal ulcer.

10. **Acute Pancreatitis.**—Acute pancreatitis if encountered during the first twenty-four or forty-eight hours of its existence is confined to the right upper quadrant of the abdomen and can frequently not be differentiated from perforating duodenal or pyloric ulcer or from perforation of the gall-bladder but later the infection extends downward and then the diagnosis can usually only be made positively after an exploratory incision. In many cases a hard tumor may be felt in the region of the pancreas. There is often a history of previous attacks of deep-seated pain in this region. Occasionally glycosuria is present and sometimes fatty diarrhœa. The shock is usually intense and the center of greatest pain as well as tenderness upon pressure remains in the region of the pancreas.

11. **Acute Indigestion.**—Until very recently acute appendicitis was frequently mistaken, especially in children, for acute indigestion chiefly because the diagnosis was made from the history of some indiscretion in eating without any physical examination being made.

If gastric lavage is made, all symptoms will speedily disappear in acute indigestion while in acute appendicitis the area will remain painful upon pressure over the appendix.

13. **Intestinal Obstruction.**—In this condition pain and shock are severe and the vomiting more severe and persistent than in appendicitis. The pain does not change to the right inguinal region unless the obstruction is due to intussusception of the ileum into the cæcum which is the most common form of intestinal obstruction in children. In adults it is more likely to be due to volvulus or bands. In these cases the

temperature is usually normal or subnormal until peritonitis occurs when both temperature and pulse rise rapidly. In appendicitis the temperature is usually abnormal from the beginning and the vomiting is not nearly so persistent and it rarely becomes stercoraceous.

14. **Thrombosis of Mesenteric Vein.**—If the vein involved is in the right iliac region it is scarcely possible to make a differential diagnosis although the presence of an endocarditis with valvular lesions is likely to bring to mind the possibility of the presence of a thrombosis of the mesenteric vein. Later, blood in the stools may confirm this suspicion but usually the diagnosis is made after the abdomen has been opened.

15–16–17. Tuberculous or simple ulcers or tumors of the cæcum or ascending colon can be differentiated only when a definite circumscribed tumor can be recognized by palpation; otherwise an exploratory incision will be required to make a differential diagnosis.

18. **Tuberculosis of the spine,** with incipient psoas abscess. This condition can usually be recognized by making pressure over the spinal vertebræ. The condition is chronic and occurs in patients having the appearance of tuberculous subjects. There is commonly an afternoon elevation of temperature with a normal or subnormal morning temperature. Later on a fluctuating swelling can be palpated. There is generally flexion of the thigh which may occur in appendicitis if the appendix is adherent to the anterior surface of the iliacus muscle but in that case it can usually be palpated and there is no tenderness upon pressure over the spinous processes of the vertebræ.

19. **Pyosalpinx.**—This can usually be palpated distinctly through the vagina. The initial pain is likely to be in the lower portion of the abdomen and not in the region of the umbilicus and the pain upon pressure is lower than in appendicitis.

20. **Ovarian Cyst with Twisted Pedicle.**—The pain in this condition comes on very suddenly and usually after the patient has lifted something heavy or has made some rapid motion or unusual exertion. Aside from the above the symptoms just described in connection with pyosalpinx would apply to this condition.

21. **Abscess of Ovary.**—The symptoms mentioned for pyosalpinx apply to this condition in every particular.

22. **Abscess of Abdominal Wall.**—In this condition the extraperitoneal location of the infection can readily be recognized by careful palpation.

23. **Incipient Inguinal Hernia.**—Before the hernia has reached the external abdominal ring it is often very difficult to obtain a definite impulse upon coughing and it may be difficult to differentiate between it and subacute appendicitis.

24. **Dysmenorrhœa.**—This often accompanies subacute appendicitis; its periodicity should, however, prevent errors in diagnosis. It is not infrequently the case that appendicitis causes dysmenorrhœa.

25. **Inflammation of the Right Spermatic Cord.**—In these cases there is usually a history of a specific urethritis or a tuberculous or specific epididymitis can be recognized.

26 **Tuberculous peritonitis** is chronic in character; there is usually pn afternoon elevation of temperature and frequently free fluid is aresent in the peritoneal cavity.

27. **Pleurisy** has been repeatedly mistaken for appendicitis, because in case of a very severe acute onset of pleurisy there is often a marked degree of contraction of the abdominal muscles. The diagnosis can be made by palpation of the abdomen together with careful auscultation of the chest which will show friction, the characteristic signs of pleuritis.

29. **Herpes Zoster.**—Before the typical eruption appears the severe pain at the beginning of an attack of herpes may readily be mistaken for acute appendicitis; this will, however, be cleared up as soon as the eruption appears.

30. **Hysteria** may simulate any disease. It may of course occur simultaneously with appendicitis and it is consequently important to study the neurotic patient with great care before making a negative and with even greater care before making a positive diagnosis.

Many other conditions have been confounded with acute or chronic appendicitis but it seems scarcely necessary to draw out this discussion still further. *It seems proper, however, at this point once more to insist upon the importance of making a careful physical examination in every case showing symptoms of any abnormal intra-abdominal condition. I would also repeat the caution against violence in palpation because it is one of the useless methods which is distinctly dangerous to the life of the patient.*

Treatment.—The ideal treatment of appendicitis consists in removing the cause by removing the diseased appendix. In every case there is a time when this can be done with almost perfect safety by any surgeon who has a sufficient amount of skill and experience to perform safely any intra-abdominal operation. It is a good rule for every surgeon to determine whether he can remove the diseased appendix in the

individual case under consideration with safety to the patient. If, judging from his previous experience with patients in asimilar condition, the surgeon is reasonably certain that he has the required skill and facilities to perform this operation safely in the case before him, then he should urge the patient to submit to the operation. This does not mean that he should urge an operation in every patient suffering from appendicitis; neither does it mean that he should do this in cases which could be operated on safely by a surgeon of much greater skill with better assistants and better hospital facilities because these conditions are likely to coexist, but he should take into consideration the degree of his own skill or lack of skill and all of the other conditions which have a bearing upon the prognosis in the case as well as the condition of the patient. This applies particularly in cases of acute appendicitis seen by the surgeon before the infection has extended beyond the tissues of the appendix proper which is usually the case before the end of the first 48 hours after the beginning of the attack. In cases of chronic appendicitis it is always possible for the patient to place himself in the care of a surgeon of whose skill there can be no doubt; the same is true of recurrent cases. The reason for urging the removal of the appendix while the infection is still located in the appendix lies in the fact that by doing this the patient can reasonably expect to recover perfect health within a few weeks without running the risk of developing any of the many complications which have already been enumerated and which not only endanger the life of the patient directly but also give rise to conditions which ruin the health, happiness and prosperity as well as the life expectancy of thousands of individuals. All of these disasters can be avoided by a safe early operation done by a surgeon of even moderate skill.

These remarks apply to an even greater extent in children than in adults because in many of the former it is difficult to eliminate peristalsis by gastric lavage. Moreover, in children the omentum is frequently of little use for the purpose of segregating the appendix from the general peritoneal cavity because it is not as yet of sufficient size and thickness to provide an efficient cofferdam around the diseased appendix. Young patients bear an early operation exceedingly well and it is consequently wise to operate on children at once under conditions which might not be quite good enough to warrant an operation in the adult. *Too much stress cannot be laid upon the importance of invariably making an early diagnosis and of removing the appendix while all infectious material is still confined to the appendix.*

It has frequently been said that an immediate operation is indicated invariably because it is impossible to prognosticate what will happen in any individual case of acute appendicitis. In the adult fortunately this is no longer true. In any case of acute appendicitis in the adult it is quite possible to tell what will happen so long as the surgeon controls the treatment of the patient absolutely. If, after making gastric lavage, peristalsis is inhibited by absolutely preventing the ingestion by mouth of cathartics and food of any kind (which means that one must forbid giving by the mouth even broth or other liquids including champagne and at first even water), then one can predict with almost absolute certainty that if the patient be kept in bed with the head of the bed elevated to 30° or more and if the appendix is not disturbed by manipulations for diagnostic or any other purposes there can be only one of two results: the condition may subside, absorption of the inflammatory tissue taking place; or a circumscribed abscess may form which may safely be drained as soon as it can be recognized. It is important never to make a violent examination for the purpose of determining the presence of a localized abscess. It is extremely rare for a case of acute appendicitis to take a different course from that described above if the treatment mentioned is carried out. It is quite another matter in cases in which even only a small amount of food or cathartics is given by mouth or in which gastric lavage is not practised, because in these cases the peristaltic action of the intestines has not been inhibited and consequently the infectious material may be carried from its safe circumscribed area to other portions of the peritoneal cavity. Under these circumstances it is true that one cannot tell what will be the outcome but an unfortunate outcome should be distinctly charged to the treatment and not to the disease.

In order to give a clear expression of my views concerning the mortality in patients suffering from appendicitis and the methods indicated for lowering this mortality it may be well to repeat certain conclusions which were formulated after a very extensive observation of all forms of appendicitis.

It seems in the ultimate analysis that the mortality results from infection which has been carried from its original location in the appendix to points more or less distant, in most instances by being dislodged from its original location by means of the peristaltic action of the small intestines and that in each case there was a time when this could have been prevented by the removal of the appendix.

In other cases the infection, which had already passed beyond the

tissues of the appendix, has been carried to other portions of the peritoneal cavity as a result of the manipulations during an operation for the removal of the appendix. If the following conclusions are carried out in detail in practice these two sources of fatal infection may be almost completely eliminated.

Conclusions regarding Treatments.—1. Patients suffering from chronic appendicitis should be operated upon.

2. *Patients suffering from acute appendicitis should be operated upon as soon as the diagnosis is made, provided they come under treatment while the infectious material is still confined to the appendix, and provided that a competent surgeon is available.* Besides insuring a low mortality this will prevent all serious complications previously mentioned.

3. In all cases of acute appendicitis, without regard to the treatment contemplated, the administration of every kind of food and cathartics by mouth should be absolutely prohibited and large enemata should never be given.

4. In case of nausea or vomiting, or gaseous distension of the abdomen, gastric lavage should be employed.

5. In cases coming under treatment after the infection has extended beyond the tissues of the appendix, especially in the presence of beginning diffuse peritonitis, conclusions 3 and 4 should always be employed until the patient's condition makes operative interference safe. It is well to place all of these patients in the Fowler position.

6. In case no operation is performed, neither nourishment nor cathartics should be given by mouth until the patient has been free from pain and otherwise normal for at least four days. The same practice should be followed after operation.

7. During the beginning of this treatment not even water should be given by mouth, the thirst being quenched by rinsing the mouth with cold water, by the use of chewing gum and by the use of normal salt solution or plain warm water by rectum by the drop method or by Murphy's method of proctoclysis. Later, small sips of very hot water frequently repeated may be given, and still later small sips of cold water. There is danger in giving water too freely, and there is great danger in the use of large enemata.

8. All practitioners of medicine and surgery, as well as the general public, should be impressed with the importance of prohibiting the use of cathartics and food by mouth, as well as the use of large enemata, in cases of patients suffering from acute appendicitis.

9. It should be constantly borne in mind that even the slightest amount of liquid food of any kind given by mouth may give rise to dangerous peristalsis.

10. The most convenient form of rectal feeding consists in the use of 1 oz. of one of the various concentrated liquid predigested foods in the market, dissolved in 3 oz. of warm normal salt solution, introduced slowly through a soft catheter inserted into the rectum a distance of 2 or 3 in.

11. *This form of treatment cannot supplant the operative treatment of acute appendicitis*, but it can and should be used to reduce the mortality by changing the class of cases in which the mortality is greatest into another class in which the mortality is very small after operation. This applies particularly to severe acute perforative or gangrenous appendicitis more than 36 or 48 hours after the beginning of the acute attack.

These conclusions have been repeated constantly during the past 14 years. They are so simple that it does not seem possible that they could be misunderstood. Notwithstanding this fact many of the most important features seem to have been overlooked by those who have considered these views in their discussions. This is true especially of conclusions 1 and 2 which are the most important of all conclusions and which if carried out in all cases would make all of the other conclusions almost unnecessary. *It is important, consequently, to insist upon the importance of removing the appendix in every case in which the infection is confined to the appendix without regard to the other conclusions.*

Conclusion 2 gives most excellent reasons why conclusions 1 and 2 should be carried out.

Many practitioners and some surgeons seem to have the idea that conclusion 3 needs to be heeded only in severe advanced cases. It is true that it is imperative to apply this conclusion in severe cases but if it were applied to all cases there would be developed but very few severe ones.

Conclusion 4.—Strange as it may seem we constantly meet cases in which there has been severe persistent vomiting in which the physician has not made use of gastric lavage because he has labored under the impression that because of the fact that the patient has vomited so freely it is not necessary to perform gastric lavage. To their surprise we have many times emptied from several ounces to pints of offensive stomach contents in these cases, this substance being so offensive that no healthy person could possibly maintain even the smallest portion of

it in his stomach. These patients improve so marvelously after their stomachs have been relieved of this substance by gastric lavage that one demonstration invariably makes a permanent convert of the most incredulous practitioner.

Conclusion 5 is of the very greatest importance. Almost all the fatalities following immediate operation occur in cases to which this rule applies. By observing this rule the mortality can be reduced to less than 2 per cent.

During operation performed after infective material has passed beyond its primary location in the appendix itself there is danger of carrying some of the infection to a point from which a general sepsis can occur and lead to death. It does not matter that we know some surgeons possessed of so much skill and judgment that they can by operation save a high percentage of their patients. The important fact remains that many cases are *not* diagnosed and operated on early (as they should have been) and that we have a means by which approximately 98 per cent. of patients in a very critical condition may be saved by anyone possessing a sufficient amount of intelligence and "backbone" to carry out the simple directions formulated in conclusion 5.

The treatment must be kept up until "the patient's condition makes operative interference safe." This is the case when a circumscribed abscess has formed or when the acute condition has been changed into one suitable for an interval operation. In the former case any physician can open the abscess with safety if he does nothing beyond opening and draining it; in the latter a surgeon of average skill can perform the operation safely and if there is no such surgeon locally available the patient can safely go any distance to find such an one.

In the meantime if the patient's diet is confined entirely to liquids there is not the slightest danger of a recurrence, no matter how long the radical operation has to be postponed.

It is most important to remember that should the rule be to operate at once on the cases referred to in conclusion 5 then necessarily this most serious operation would in the majority of instances be performed by men of very moderate skill, by men having sufficient skill and experience to perform an interval operation or one within the first 24 or 36 hours after the beginning of the attack but who are not qualified to undertake any operation in which experience, skill, surgical judgment and above all, time, are of such vital importance as they are in the class of cases under consideration.

Conclusion 6. It is not an uncommon mistake for physicians to

consider mild cases of appendicitis not sufficiently ill to demand an operation and on the same basis not sufficiently ill to be deprived entirely of the use of food and cathartics by mouth. I have seen many deaths which were due to this lack of judgment. An appendix with a circumscribed gangrene may give but slight symptoms because the defect is protected by the omentum, the cæcum or the parietal peritoneum but a little food or cathartic may cause a sufficient disarrangement of this physiologic protection to result in a little leakage which will in turn change a perfectly safe condition into one of the most dangerous intra-abdominal conditions. It is important not to give food too early but to wait until the patient has been normal in every way for at least four days and then to begin with thin beef tea, and later broth and not to give milk for a week or 10 days longer.

Conclusion 7.—I have made this conclusion so definite because I have found so frequently that the practitioners will content themselves by telling the patient to take nothing to eat or to drink only to find the next day that some friend has administered milk or soup or broth or champagne or any other imaginable liquid under the supposition that any one can take these things safely at any time. Many a life has been lost because the directions were not sufficiently definite.

Conclusion 8.—It is really worth while to impress this rule upon all who come into contact with patients suffering from appendicitis because it matters not what other method of treatment may be contemplated the results will be better if neither food nor cathartics by mouth nor large enemata are given to any of them.

Conclusion 9 is covered by the argument made in the discussion of conclusion 7.

Conclusion 10.—If a non-irritating commercial liquid food is used in normal salt solution, almost every patient will retain it well, provided it is given very slowly through a small catheter introduced a distance not to exceed 3 in. If given under pressure with a fountain syringe it often causes an irritation. If there is any irritation notwithstanding the fact that the above method is employed, it is well to add from 10 to 30 drops of deodorized tincture of opium to each of the rectal feedings according to the age, weight and general condition of the patient.

In case the patient suffers pain after gastric lavage has been employed, it is well to add the deodorized tincture of opium with each rectal feeding until the pain has disappeared.

The rectal feeding ought to be repeated every three or four hours.

Conclusion 11.—Ever since I first announced the value of this form of treatment at the International Congress in Paris in 1900, 14 years ago, I have insisted upon its limitations and particularly upon the fact that it *should never be employed as a means of avoiding an early operation with its almost absolute safety for the life of the patient and the relative certainty of its preventing all of the serious complications*, but too much stress cannot be placed upon its actual value in changing cases which are in a dangerous condition, because they have come for treatment too late for an early operation, into cases which can safely undergo surgical treatment later.

Operative Treatment of Appendicitis.—*Incision.*—In choosing an incision for the removal of the vermiform appendix one must take into consideration the extent of the intra-abdominal manipulation that will be required, the extent to which it will be necessary to expose to view the intra-abdominal structures, the presence of complicating conditions which must be relieved at the same time (such as diseased conditions of the uterus, ovaries or tubes in the female, conditions causing chronic obstruction of the intestines and consequent intestinal stasis), the presence of gall-stones, gastric ulcer or other pathological intra-abdominal lesions.

It is important that the incision furnish ample room to remove the appendix without infecting surrounding tissues; at the same time provision must be made in case an abscess is present to provide satisfactory drainage. The incision should always be so planned as to give the greatest possible guarantee against post-operative ventral hernia, except when an appendiceal abscess is simply drained without removal of the appendix. In this class of cases it is usually an advantage to have a ventral hernia, because its presence usually encourages the patient to submit to a second operation at which time the appendix can be removed safely.

In operation for early acute appendicitis while the infection is still confined to the appendix, the McBurney incision is very satisfactory. A point one-half the distance between the umbilicus and the right anterior-superior spine of the ilium is chosen and an incision is made parallel to Poupart's ligament in such a manner that the above point is near its center. The length of the incision must depend upon the whim of the surgeon, as it is quite immaterial to the success of the operation so long as it is sufficiently long to permit the necessary manipulations without unnecessary traumatism to the tissues. The incision is carried through the skin, the superficial fascia and fat and through the aponeurosis of the

external oblique, care being taken to split but not to cut the fibers of this aponeurosis. The edges of the wound are now retracted and the fibers of the internal oblique are seen extending at right angles to the original incision. These fibers in turn are separated but not cut. The incision through the internal oblique muscle is at a right angle to the primary incision. The transversalis fascia is now exposed and is split together with the peritoneum either transversely or obliquely. This exposes the intestines.

The subsequent steps of the operation are the same no matter what the form of incision; consequently it will not be necessary to discuss them at present.

In case it is found after the peritoneum has been opened that the condition present requires a larger abdominal wound for the safe completion of the operation, the wound can conveniently be enlarged by a plan devised by Robert Weir. The aponeurotic incision is continued toward the middle line to divide both the anterior and posterior layers of the sheath of the rectus. The rectus muscle is retracted inward and with it the deep epigastric vessels, or these latter may be divided between ligatures. After the intra-abdominal portion of the operation has been completed, these structures are carefully reunited by means of chromicized catgut sutures and then the wound is closed as though the extension had not been made.

All abdominal wounds are closed by means of sutures uniting each successive layer separately with the greatest possible accuracy, the peritoneum being turned outward in order to prevent the protrusion into the peritoneal cavity of raw surfaces. The suture material may consist of any good preparation of catgut which will resist absorption for at least 10 days, or chromic gut which will be absorbed between the fifteenth and twentieth day, or fine silk, fine linen or very fine bronze wire. Our preference is catgut. The skin wound may be closed in any way desired by the surgeon. We prefer horsehair.

Incision in Cases Requiring a Large Wound.—In many cases it is clear at the outset that a large wound will be required, and in these it is well to choose either the median incision, if there are probably complications involving the pelvic organs, or an incision parallel to the external border of the right rectus abdominis muscle and from 2 to 3 cm. internal to this border. This incision may be made as short or as long as the conditions may require. It may be made short at first and then lengthened during the course of the operation if it seems that this is desirable. The incision passes through the skin, superficial

fascia and fat, and then through the aponeurosis in front of the rectus abdominis muscle; then the muscle is split longitudinally about 2 cm. to the inner side of its outer border, care being taken not to traumatize the muscle unnecessarily. A few small arteries and veins will be caught in forceps, cut and ligated on both sides, and a few nerve filaments will be cut, but none of these structures are of any importance.

Occasionally the right epigastric artery and vein are in an abnormal position or they give off unusually large branches; consequently one should watch for these structures in order that they may be protected by gently drawing them inward by means of blunt retractors. It is well to be careful not to injure the veins, because it has been claimed that their traumatism is likely to result in thrombosis and that this in turn may result in thrombosis of the external iliac or the femoral vein.

The transversalis and peritoneum are then incised exposing the intra-abdominal structures.

Kammerer's Incision.—In many respects this incision is superior to the one just described because it avoids incising the rectus muscle and it enables one to make a most excellent closure of the abdominal wound. The exposure of the intra-abdominal contents is, however, somewhat less extensive in this than in the previous operation.

In this incision, after splitting the aponeurosis longitudinally parallel with the outer border of the right rectus abdominis muscle and from 1 to 2 cm. from this border as in the previous method, the outer border of the rectus muscle is loosened and drawn toward the median line, and the aponeurosis posterior to the muscle together with the transversalis fascia and the peritoneum are incised in a line corresponding exactly to the incision through the aponeurosis in front of the rectus muscle.

Kammerer's incision can be lengthened to any degree necessary, and in case it is found that the operation can be completed through a short incision all of the layers can be restored to normal in a few moments and the abdominal wall will be restored to a perfect condition, which will protect the patient against the possibility of a post-operative hernia. The patient may move about and sit and stand up at any time after the operation has been completed without danger of injury to the wound.

This incision has the advantage over the one previously described in that it avoids splitting the rectus muscle and does not produce an opening in a direct line from the skin to the peritoneal cavity, but practical

results have shown that these are only theoretic advantages and that in practice both methods are equally good.

Recently, transverse incisions have been recommended, but these cannot be considered seriously because of the fact that they offer no advantages while their disadvantages are very obvious.

Incision through the Median Line.—In cases in which appendicitis is complicated with ovarian or uterine tumors or disease of the ovaries, tubes or uterus, it is often desirable to make an incision in the midline between the pubis and umbilicus in order to obtain sufficient space to remove not only the appendix but also to do whatever may be indicated to relieve the other conditions present. The length of this incision must be regulated by the conditions encountered. In making the median incision it seems wise to lay open the aponeurosis of the rectus muscle on both sides so that these muscles may be applied directly to each other broadly when the wound is closed, thus making a thick muscular layer behind the aponeurosis of the internal and external oblique abdominal muscles. In closing the wound it is well to insert one silkworm-gut suture for every 2 or 4 cm. of the length of the wound. These sutures pass through all of the layers down to but not through the transversalis and peritoneum. They are left untied until each of the layers has been sutured separately and then are tied over all as safety sutures. Very accurate coaptation of all layers is made, preferably by means of continuous catgut sutures. Some authorities prefer very fine silk which is equally satisfactory, especially if interrupted sutures are used and if the silk is so fine that the sutures cannot be tied sufficiently tightly to cause pressure necrosis.

Locating the Vermiform Appendix.—The cæcum is easily found and recognized from its characteristic appearance. The longitudinal muscular band on the cæcum if followed will lead to the vermiform appendix at its lower end. The position of the appendix can also be determined by observing the entrance of the ileum.

As has been already stated, the appendix may be found at any point within the abdominal cavity, but by following the above guide one can always find it, although it may be surrounded by intestines or omentum or completely buried underneath cicatricial layers or bands.

In the first attack of appendicitis the appendix may be found buried under an accumulation of coagulated lymph or covered by loops of large or small intestines, or it may be partly or completely surrounded by omentum.

The cæcum having been brought to the surface and the longitudinal

band recognized, it is well to follow this until one reaches the cæcal end of the appendix as it emerges from the lower end of the cæcum. From this point on, the operation must be varied according to the experience and skill of the operator and the degree and character of the disease of the appendix. If the infection has not passed beyond the limits of the appendix it is usually easy to remove it without risk of spreading the infection. When, however, the inflammation is severe and the appendix is buried in a mass of exudate and adhesions, it may be safer for a surgeon who has not the advantage of large experience to place a gauze tampon against the infected area and only open any abscess which may be present, after adhesions have formed sufficient to protect the abdominal cavity. The patient should then be placed on liquid diet for at least three months or as much longer as he may be willing to limit himself to this diet, when the diseased organ can be removed with perfect safety by a surgeon even of a much slighter amount of skill and experience. In the meantime, the patient is not in the slightest danger of suffering from a recurrence so long as the liquid diet is maintained.

In removing a severely inflamed appendix during an acute attack, too much attention cannot be given to means of preventing infection of the surrounding tissues. One of the most important prophylactic measures lies in reducing traumatism to a minimum. It has been shown conclusively that the surrounding tissues, if not traumatized, will dispose of a large number of microörganisms capable of producing a violent peritonitis if the peritoneum has been bruised by rough handling.

The fact that an inflamed appendix is extremely brittle should also be borne in mind throughout the operation, lest some careless motion tear the wall of the organ and permit its contents to escape and infect the surrounding peritoneum.

It is well to protect the surrounding peritoneum by careful tamponing with soft pads of gauze moist with normal salt solution. The tampons should be applied with great care in order not to bruise the peritoneal surfaces.

It is important to make the abdominal incision long enough so that the entire operation can be performed in clear view without traumatizing the wound edges unduly with retractors.

Removal of the appendix is often greatly facilitated by clamping it at its cæcal end with two strong artery clamps of the Kocher or Ferguson pattern, then cutting off the organ between these clamps. Adhesions and the mesenteriolum are secured with further clamps and

thus the organ is dissected from the proximal to the distal end, care being taken not to exert much traction upon the clamp attached to the appendix for fear of tearing its wall and releasing its septic contents.

The appendix having thus been freed and removed, the tissues caught by the various clamps are ligated and the raw surface is carefully covered by means of fine catgut sutures.

A purse-string suture is then passed around the cæcal end of the appendix through all of the layers of the cæcum down to, but not through, the mucous membrane. At the point opposite the mesenteriolum it is well to take an additional stitch in order to grasp any small vessel which may enter the cæcum at this point. The stump of the appendix which has been held in the grasp of the forceps during this time may now be inverted into the cæcum while the purse-string suture is being tied, or a fine silk or catgut ligature may be tied about the crushed base of the stump before it is inverted so as to make doubly sure that hemorrhage may not occur. This precaution is quite unnecessary if the needle catches the submucous connective tissue when the purse-string suture is being applied. On the other hand, the ligature does not cause the slightest harm, although there may be some theoretic objections to its use.

The disinfection of the stump by means of the actual cautery or strong carbolic acid or iodoform has now been generally discarded.

A number of deaths from hemorrhage have been reported in cases in which the stump was not ligated, but undoubtedly in these the purse-string suture was not applied carefully or deeply enough or the stitch around the mesenteriolum was omitted. Preference is usually given to silk for the suture material for the purse-string suture, but fine strong linen or Pagenstecher are quite as satisfactory. Catgut is likely to make slight tears in the peritoneum and occasionally it absorbs too rapidly so that gaseous distention of the intestine may cause a leakage, and as no harm ever comes from non-absorbable suture materials it is better to choose one of them.

An ordinary fine, round, straight sewing needle is a little better than any other for introducing the purse-string suture because it does not cut the tissues unnecessarily. This, however, is really a matter of personal choice.

It is well to apply a second row of Lembert's sutures because occasionally the gaseous distention of the cæcum may be so severe during the first few days following the operation as to jeopardize the

security of a single purse-string, although this condition is extremely rare unless food is given too soon after the operation.

It is well to inspect the ileocæcal valve in order to determine that there is no obstruction at this point due to cicatricial contraction. It is also well to look for adhesions, a Lane's kink or a Jackson's membrane which, if present, should be treated according to the methods described elsewhere.

All raw surfaces which have been produced during the operation should be carefully covered with peritoneum by means of fine catgut sutures in order to prevent post-operative adhesions.

Suppurative Appendicitis.—When a gangrenous or perforative appendicitis has resulted in a circumscribed abscess, the operation is the same as that already described up to the point where the tissues containing the abscess have been laid bare. It is important to have the abdominal incision sufficiently long to permit of all the necessary manipulations being made without unnecessary traumatism and without the danger of soiling the surrounding peritoneum when the abscess is opened. After the surrounding peritoneum has been protected by tampons introduced with even greater care than in the previous case, the tissues are carefully separated by gentle pressure of a finger until the abscess is opened and the pus begins to escape. The pus is sponged away carefully until the abscess is entirely empty and the appendix is peeled out of its adhesions, preferably beginning at the cæcal end after severing it between two pairs of forceps. It is well to tampon the abscess cavity in the meantime with a hot gauze pad saturated slightly with normal salt solution in order to prevent unnecessary loss of blood from oozing. The stump and mesenteriolum are cared for after the manner described above.

The question of drainage must now be considered. In a general way it always seems best to drain where one has a right to fear peritoneal infection in its absence, and in any case in which there is the slightest doubt.

Method of Drainage.—It is always best to carry the drain through an opening separate from the primary abdominal incision in order that the latter may heal primarily. In connection with any one of the longitudinal incisions a point a few centimeters to the right of McBurney's point seems to be the most favorable for this purpose. An incision 3 cm. long should be made parallel with Poupart's ligament through the skin, fat and fascia, and after splitting the fibers of the aponeurosis of the external oblique a pair of forceps is forced bluntly into the peritoneal

cavity between the fibers of the internal oblique and the transversalis muscles and through the peritoneum. The jaws of the forceps are then separated and the opening made sufficiently large to permit the introduction of two fingers. Through this opening any one or any combination of the following drains may be introduced to the bottom of the abscess cavity: (*a*) a glass tube covered with gauze; (*b*) a split rubber tube with or without a strand of gauze in its lumen and with or without a piece of gauze over its surface; (*c*) one or more cigarette drains; (*d*) a strip of gauze tape or wicking. If the omentum is present it should be carefully placed about this drain in order to shut it away from the other intra-abdominal organs.

It is well not to give either food or cathartics by mouth in these cases for a number of days after the operation in order to prevent the possible distribution of septic material by means of peristalsis, the necessary nourishment and water being supplied by nourishing enemata and by the instillation of normal salt solution or water into the rectum by Murphy's method of proctoclysis.

Frequently before perforative appendicitis comes under treatment it is so far advanced that an abscess can be recognized by palpation and percussion. In these cases it is well to make an incision over the most prominent portion of the swelling and to open the abscess freely. In a general way, the farther away from the median line of the body it is possible to open such an abscess the better it will be, because the subsequent adhesions will be correspondingly less troublesome.

In these cases of abscess the treatment must vary with the skill and experience of the surgeon in charge. A surgeon with moderate skill should usually do nothing beyond opening the abscess and introducing one or more of the various drains just described, because in this manner he can be practically certain of the ultimate recovery of the patient provided he does not permit the use of food or cathartics by mouth until the bowels have been evacuated spontaneously, and even then permits the use of liquid food only until the appendix has been removed and milk only after the patient has been in every way normal for a number of days.

A surgeon with more skill may safely remove the appendix in a majority of these cases provided he does not attempt to do so when it seems likely that it will result in spreading the infection to other portions of the peritoneum.

A few surgeons have reported that they invariably remove the appendix without regard to its location, condition or the general con-

dition of the patient at the time he comes under the surgeon's care. By classifying all fatal cases as patients suffering from diffuse peritonitis the death rate following this operation for gangrenous or perforative appendicitis will still be fairly low; yet there can be no doubt but that many cases would not reach the condition of general peritonitis if these surgeons were less radical in this class of cases and removed the appendix only in cases in which from their personal experience they had learned that it could be done safely.

Important as may be the careful choice of operation in severe appendicitis the after-treatment is much more important. Within one month I have been consulted personally in six of these cases (one of them proving fatal and all being considered hopeless by the surgeons in charge) because the attendants had not appreciated the importance of three very simple rules which should be a part of the routine in the after-treatment. 1. Never give anything by mouth, least of all a cathartic for several days after operation and until gas has passed freely by the bowel.

The patients never suffer because of this. All necessary fluid can be supplied by means of protoclysis by the drop method. To the fluid may be added a sufficient quantity of one of the various concentrated liquid, commercial, predigested foods to prevent hunger. If the patient is given gum or the stone of some fruit to chew, thirst will not be distressing and the saliva secreted will prevent the formation of parotitis. 2. The moment there is any gaseous distention, gastric lavage should be resorted to. It is usually best to give a hypodermic injection of one-quarter of a grain of morphia and one-hundredth of a grain of atropin hypodermically, then to wait one-half hour, anesthetize the pharynx with a 2 per cent. solution of cocaine, wait 5 or 10 minutes and then introduce the stomach tube and irrigate the stomach thoroughly with water or normal salt solution at 105°F.

The morphine and cocaine prevent the patient from harming himself by severe gagging. It is well to have the patient lie on the side while this is being done.

In cases in which there are apparently complications in the pelvic region it is much better to make the primary incision in the median line even if there may be a further complication with gall-stones. In case drainage of the region of the appendix is required it can readily be provided through an additional opening to the outside of McBurney's point.

If gall-stones are found the gall-bladder, cystic duct, hepatic and common ducts can readily be palpated through the abdominal incision.

If all the stones are in the gall-bladder they can be readily removed through a small incision directly over this organ.

If they are located in the ducts it is better to permit the patient to recover from the primary operation and later to make a secondary operation for the removal of the gall-stones.

SECTION V

THE LARGE INTESTINE (CÆCUM, COLON, SIGMOID)

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Anatomy, Embryology and Physiology.—The large intestine is morphologically a harmonious whole, but functionally it retains its primitive characteristics. The division of the primitive gut into fore, mid- and hindgut is not an arbitrary one, but based on a sound theory of development.

The derivatives of the foregut, composed of the stomach, duodenum above the common duct, liver and pancreas, have a common blood supply in the celiac axis and are concerned in the preparation of food for digestion, but do not themselves absorb. The movement of the food material is onward (peristalsis).

The remainder of the duodenum, the jejunum, ileum, and the colon, as far as the splenic flexure, are derived from the midgut. All of these organs are concerned in the actual absorption of food products; their blood supply comes from the superior mesenteric artery. Here too the peristaltic movement is onward.

The remainder of the large intestine is developed from the hindgut and derives its nourishment from the inferior mesenteric artery. It is non-absorbent, it serves largely for storage purposes and, except during defæcation, the movement of its contents is backward (antiperistalsis).

The rectum and bladder are derived from the hindgut but were differentiated from it at an early stage through the development of the cloaca of which they are the direct offspring. Correct anatomic definition[1] shows clearly that the so-called first portion of the rectum (American Anatomists) is really the terminal portion of the pelvic sigmoid. New growths in this region are essentially sigmoidal in character and related to the colon rather than the rectum, in blood, nerve and lymphatic supply.

A clear conception of the dual character of the large intestine is

essential to a proper understanding of its various diseases. In relation to rectal feeding, it has been shown that particles placed into the rectum are promptly carried by reverse peristalsis to the absorbent half of the large intestine, which lies proximal to the splenic flexure.[2] The long colonic tube which is frequently supposed to be passed through the rectum into the sigmoid in reality passes in out of sight through the anus to coil itself within the rectum without entering the sigmoid.

The anatomic nature of the termination of the sigmoid at the recto-sigmoid junction is such that passage of a tube cannot occur except under most unusual conditions.

In the early stage of development of the large intestine, the mucous membrane of the cæcocolon (head of the colon) possesses villi similar to the small intestine. These villi later disappear, the mucous membrane becomes pale and gray, but its ability to absorb is by no means lost.

Ten per cent. of the solids and 50 per cent., of the fluids are absorbed in the large intestine before they reach the splenic flexure. In the small intestine the fluids are used to float the food-mass as far as the cæcum and keep it in contact with the intestinal villi. The alkaline content of the small intestine is changed to acid on reaching the cæcum, largely by means of colon bacteria, which have become "harnessed" for work. The acid condition of the secretion of the large intestine is not normal; on the contrary the secretions are normally alkaline. The propulsion of food in the large intestine does not depend wholly on peristalsis, but, to a certain extent, on the development of gases. The stool is composed of food remnants that have become the basis of large bacterial growths, giving bulk to the excreted mass. The brownish color of the fæces is derived, not from the bile alone, which would leave it more or less of a clay color, but by a combination of the biliary and pancreatic secretions aided by bacterial growth.

The large intestine comprises one-fifth of the length of the entire intestinal tract, and is from 5 to 5½ ft. in length. The proximal half is highly differentiated and has more fixed characteristics because of its long heredity. In many animals there is cæcocolic sphincter which aids in the retention of food material for a longer time in the absorbing part. In man the remnant of it is found as the reticularis. The large intestine is 3 in. in diameter at the cæcum and gradually reduces in size to the sigmoid, which is the smallest part.

In the cæcum the longitudinal bands are somewhat widely separated. In the sigmoid they are naturally brought closer together and finally spread out, completely enclosing the rectum.

The sigmoid is composed of two parts. The part which is attached to the iliac bone is 5 or 6 in. in length and the pelvic or free sigmoid which is 16 to 17 in. in length. The sigmoid varies greatly in size and length because of its short heredity.[3] It is very large in the new-born infant and does not shrink, but the remainder of the intestinal tract grows with more rapidity until at adult age normal proportions are reached. The descending colon is usually empty, acting only as a passage way into the sigmoidal chamber.

The large intestine in a general way may be said to be formed on the left side of the body, and the small intestine in six primary convolutions on the right side. About the tenth week the head of the colon begins to rotate across to the right side and descends, to reach its normal position about the second year after birth.

Usually in referring to the cæcum, which is only from 1½ to 3½ in. in length, the cæcum and ascending colon are indicated. The cæcocolon is, functionally, the most important part of the large intestine. Of late the large intestine has become unusually conspicious through the work of Lane,[4] who believes that in this organ lies the secret cause of certain bodily disorders such as rheumatoid arthritis and those diverse disturbances of the nervous system which are referred to in a general way as neurasthenia, intestinal toxæmia, etc.

Certain fundamental facts lend some color to Lane's theories. We know that carnivorous animals have a small cæcal pouch and no appendix and that the large intestine resembles the small intestine so closely as to require close inspection to differentiate them. In herbivorous animals the cæcum is very large, as is the whole of the large intestine. It may be surmised that man, at some time in his existence, has been more herbivorous than at present, as shown by the possession of a semi-herbivorous cæcocolon and it may be further speculated that man is at present developing more marked carnivorous tendencies and that the large intestine, embryologically an herbivorous organ, is now being put to carnivorous work. We know that decomposition of vegetable matter produces fermentation with the development of chemical bodies lacking the poisonous characteristics of the putrefactive changes which take place in the decomposition of meats. It may even be possible that poisons are thereby produced and absorbed in the large intestine without appreciable physical change in the gut itself and which may have some such effect as Lane describes. An analogy exists in the hyperthyroidism of Graves' disease. In this disease, the difference in the

gland is about the difference of the lactating and the non-lactating breast.

That the cæcocolon is metabolically very important is shown by the profound anæmia which often accompanies tumors of this region and which is not accounted for by loss of blood, etc.

Anomalies, Adhesions, Stasis, Enteroptosis and Giant Colon.—Failure of the head of the colon to rotate and descend may leave the cæcum entirely on the left side of the body, or it may be found permanently situated at any point between its origin and normal location. Its attachments to the abdominal wall vary considerably. It may be closely held, as shown in the text-books, or it may be loosely held with great mobility of the cæcocolon, transverse colon and sigmoid. As the cæcocolon arrives late at its final resting place, the peritoneum may already be formed and its attachments on the right side of the abdomen may resemble vascularized adhesions, which Jackson has described as a "veil."[5] The lop-sided condition of the cæcum is due to the early adhesions of the terminal ileum to the cæcum at the ileocæcal valve, which adhesions extend to the right iliac fossa, holding it in place. An excess of this attachment gives rise to the condition known as "Lane's kink."

The transverse colon is about 22 in. in length and has 11 in. to travel. Its attachments in the center are to the movable stomach as well as to the posterior abdominal wall. Variation in position of the stomach and in the length of the posterior attachments may permit the transverse colon to prolapse, even to the pelvis. Variation in the peritoneal attachments of the large intestine produces the various fossæ or peritoneal pockets, which occasionally have pathologic significance. It should be noted that the inner leaf of the attachment of the large intestine contains the blood, nerve and lymphatic supply and that the outer peritoneal attachments are of no importance, except to hold the intestine in its place. By dividing this outer attaching peritoneum, the large intestine can be lifted on the inner vascular leaf and readily be brought outside the abdomen. The splenic attachment, derived from the omentum, contains a blood-vessel which must be ligated when divided. The splenic flexure of the large intestine is its most fixed part and is held high so as mechanically to retain food products in the absorbing portion.

The variations in size, position and attachments of the large intestine have given rise to the *mechanical* theory of colonic disease. It is believed that these variations are the cause of intestinal *stasis*

and that many diseases, in which constipation and nervous conditions are prominent features, are the result. As the large intestine itself is not hypertrophied, but rather thin walled and ballooned in these cases, the mechanical theory does not offer adequate explanation for the phenomena.

I would refer here to the original papers by Lane,[4] Jackson,[5] Coffey,[6] Eastman,[7] Binnie,[8] Summers,[9] Royster,[10] Flint,[11] Gerster,[12] and others on intestinal stasis, as well as to the discussion before the Medical Society of London.[13] Lane strongly advocates ileocolostomy or short-circuiting for the relief of intestinal stasis and certainly there are many splendid results from this operation. Unfortunately, in about 30 per cent. of cases, the retained and functionally inert large intestine becomes troublesome, often filling with fæcal masses by antiperistalsis. For this reason Lane now advocates removal of the large intestine to the point of anastomosis. This operation has its unfortunate aspect since it removes all of the omentum which may result in extensive intestinal adhesions. Moreover, it is often a more serious operation than the condition would warrant, especially in males. Lane believes that short-circuiting is sufficient in children and in adults when the colon is closely held, and further, that colectomy is usually necessary when the large intestine is freely movable. In the few cases observed in our clinic in which it was believed the intestinal stasis required operation, the removal of 10 in. of the ileum, the cæcum, ascending and half of the transverse colon, has been an efficient and safe procedure. Lane, with his large experience, is convinced that this is not sufficiently radical.

In 1885 Glenard[14] described a disease which takes his name. The disease is characterized by a loose attachment of all of the abdominal viscera; the intestine, stomach, and kidneys being prolapsed sometimes to a remarkable degree. This disease is often accompanied by poor nutrition, functional cardiovascular disorders and general nervous debility.

Vigorous attempts have been made to reattach these organs in normal position, with the expectation that the patient would thereby be restored to health. One after another, operations for the relief of enteroptosis, for example, nephropexy and gastropexy, have been brought forward but, generally speaking, they have not maintained a sound position in surgery.

Congenital absence, in part or whole, of the colon and congenital strictures have been reported in the literature, but are too rare to

require discussion in this brief synopsis. However, there is one condition of very great importance which probably belongs to this group—that is, the so-called "giant colon" or "Hirschsprung's disease." These names are given to those extreme manifestations of colonic distention and hypertrophy of which we have frequent examples in minor degrees. The condition usually involves the sigmoid and terminates at the recto-sigmoid. Gigantism of the colon is usually confined to the sigmoid, but may involve the entire large intestine. Its termination is always sharp and well marked but its beginning usually fades into the large intestine above. The affected colon may almost fill the abdomen and, on inspection, has much the appearance of a greatly distended stomach. The walls of the intestine, including all of the coats, are greatly thickened, especially the submucosa, and the mesentery may be excessively thick. The condition is most often seen in childhood, but may not become a prominent feature until adult life. Obstipation of the most severe character with abdominal distention are the prominent features. The victim often passes weeks or even months with little or no alvine evacuation. If a child, the mother has usually found that after great effort following repeated enematas and the use of the tube, an enormous quantity of foul gases and thin intestinal contents were evacuated. This insures relief until a reaccumulation takes place.

The most effective treatment for this condition is resection of the affected area. This cannot always be done at a single operation; a preliminary colostomy may be necessary and many operators have contented themselves by leaving this opening as a permanent escape for the fæcal matter.

That the cause of this condition is congenital and concerned with the mechanism of the recto-sigmoidal juncture, is made probable by the condition of the bowel, which is such as would be expected from obstruction. In all of the cases in our clinic primary excision has been practised, a time for the operation being chosen several days after the last periodic evacuation of the intestinal contents. It usually is not possible to resect down to the point of obstruction at the recto-sigmoid, but by making the anastomosis as low as possible so that when completed there is a certain amount of traction upward, the operation has never failed to result in a cure. In one of our cases[15] the transverse colon alone was involved, a huge mass of hardened fæces formed a tumor-mass much larger than the patient's head, a certain amount of fæces passing continuously through a groove in the top.

Diverticula, Infections, New Growths.—Diverticula of the intestinal tract may be congenital or acquired. Congenital types like Meckel's are almost always attached to the ileum, but through errors of development, the vitelline duct may join the large intestine and result in a Meckel's diverticulum attached to the large intestine; the resulting band may cause strangulation of the intestine. Such a band is usually comprised of the blood-vessel and the tissues about it and not the diverticulum itself.

FIG. 73.—Diverticulitis, (H 1903) × ⅔ diam. Sigmoid open longitudinally. A diverticulum containing a sloughing ulcer is seen at the lower right hand; another is sectioned near the label needle.

Acquired diverticula, especially of the sigmoid, are of very great surgical importance and have only recently become understood. It has been known for many years that occasionally an individual, usually a fleshy, elderly male, suffered from a left-sided inflammatory disorder in the abdomen, in which a tumor tender to the touch was discoverable. Constipation, a moderate amount of fever, and symptoms of local inflammation accompanied this condition. In the course of several weeks these individuals usually recovered, the attacks to be repeated

at intervals of months or years with the same result. In some instances, these patients failed to recover; abscesses formed, which opened spontaneously into the intestine, or almost as frequently into the bladder and sometimes on the surface of the body, leaving a fæcal fistula which remained an annoying complication for years or for life, unless relieved by operation. Not all these individuals were even thus fortunate. Some died from general suppurative peritonitis, due to perforation of the abscess into the abdominal cavity. Many of these patients were

Fig. 74.—Diverticulitis. (H 1903) × 1 diam. Section through ulcerated diverticulum shown in Fig. 73.

operated on for supposed left-sided appendicular abscess, although it was noted that the appendix, after removal, either at the primary or secondary operation, did not show disease.

While these diverticula had been noted at post-mortem and occasionally diagnosed in the abscess stage, it was not until Bier[16] and Wilson[17] produced data concerning the pathology of the disease and Brewer[18] reported a case of it, that the condition became correctly understood. It is probably occasioned by gas distention which pushes the mucous membrane through little defects in the muscularis of the intestinal wall.

In the congenital forms diverticula are usually found at points where blood-vessels enter, as in the epiploic tags or in the mesenteric line.

The acquired forms may exist at any point in the intestinal wall, often involving 6 or 8 in. or more of the bowel. While they are much more common in the sigmoid, they may be found at any point in the large intestine. These little pouches of mucous membrane often contain hard bodies of fæcal material resulting in irritation and consequent infection, which give rise to the symptoms simulating appendicitis.

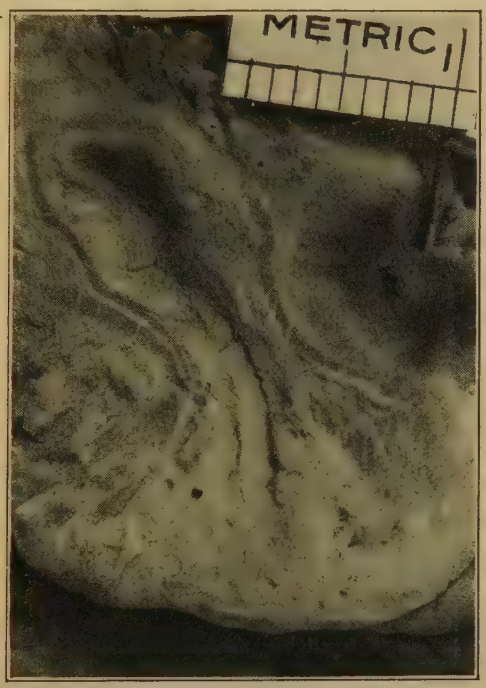

FIG. 75.—Diverticulitis. (H 1903) × 3 diam. Enlarged view of sectioned diverticulum shown in Fig. 73. Note muscularis in wall, occluded lumen and inflamed submucosa.

The chronic irritation due to the little hard masses in the pouches sometimes produces cancer. In 32 of our cases in which we excised portions of the large intestine, usually the sigmoid, for diverticulitis, six had developed cancer.

Excision is the best treatment for this condition, especially when obstruction is a marked symptom. In the acute cases with abscess, an incision for drainage should be made, reserving resection for a later time if necessary. In those cases which have established fistulæ into the bladder it is necessary to dissect the bladder free, close the fistula and

then resect the diseased gut. In elderly fleshy individuals who are poor risks for operation, rest in bed, careful regulation of the bowels and the avoidance of food which would leave irritating residue through the acute attack may be wiser than operation.

Infections.—Simple infections occur in the large intestine, producing ulcerations which may heal with the formation of stricture. In one of two cases operated on in our clinic, the patient was distinctly tuberculous, but pathologic examination after resection failed to show the dis-

FIG. 76.—Peridiverticulitis. (16736) × ⅔ diam. Inflammatory mass surrounding sigmoid dissected away, showing outer ends of numerous diverticula protruding through the muscularis. Several contain enteroliths.

tinctive characteristics of tuberculosis. Simple infections are usually located in the cæcum.

A form of acute infection, known as the "distention ulcer," which may perforate and cause sudden death, is sometimes found above chronic colonic obstructions.

A number of cases of chronic infection, not amœbic in character, have been reported in which the whole of the large intestine was involved. This condition should not be confused with mucous colitis,

which probably is neuropathic in origin and unlike the types of infective colitis, does not have blood and pus but only mucus in the stool. These diffused forms of chronic infection may last for years and appear to be but little affected by treatment. Bastianelli[19] has reported a number of cases in which extensive operation has been made. Complete physiologic rest for several months, as advocated by Brown,[20] is undoubtedly our best resource in the more severe forms of suppurative colitis. This is brought about by completely dividing the ileum from its cæcal attachments, bringing the end out and suturing it to a tube.

FIG. 77.—Peridiverticulitis. (18856) × ⅔ diam. Specimen shows pocketed mucosa, section of sigmoid wall with defective muscularis, and two diverticula—one having a pin thrust through it and the other with end removed showing enterolith. The inflammatory mass has been dissected from about the diverticula. A swollen gland is shown.

Colitis from amœba is common in the Tropics and is now somewhat widespread over the North. This form of infection can easily be diagnosed by finding the specific organism in the stool. Treatment by ipecac in some of its forms is usually efficient. Appendicostomy or cæcostomy, for flushing out the large intestine, has a field of usefulness, but is less efficient than ileostomy, which diverts the entire contents of the intestine to the surface without allowing it to enter the large intestine at all.

Actinomycosis of the cæcum has occasionally been observed. This causes hard brawny so-called ligneous induration, which rapidly breaks down and forms multiple abscesses and fæcal fistulæ, extremely difficult to cure. Excision, if possible, is the best course to pursue followed by iodide of potash internally.

Tuberculosis of the large intestine is most frequent in the cæcum about the ileocæcal valves and in the beginning of the ascending colon. It is seen in two forms: (1) the ulcerous, in which excavations are to be found which quickly form intestinal and surface fistulæ, often multiple,

FIG. 78.—Peridiverticulitis. (19305) × ⅔ diam. Sigmoid divided longitudinally. Note defective musculature and the diverticula. Inflammatory mass dissected away near label needle.

discharging fæculent material and pus from mixed infection; (2) the hypertrophic tuberculosis, which is a more common form and almost always found in the cæcocolon. Ulceration is not a prominent feature; the thickening which oftentimes constitutes a tumor-like mass is composed of sclero-adipose tissue which is usually mistaken for carcinoma. The glands are always greatly enlarged. Diarrhœa, alternating with constipation and partial obstruction with tumor are characteristic conditions. Resection of the involved intestine usually may confidently be expected to cure the disease.

FIG. 79.—Peridiverticulitis. (19395) × 2½ diam. Enlarged view of two diverticula, and one point of defective musculature seen in Fig. 78.

FIG. 80.—Peridiverticulitis. (19305) × 3³⁄₁₀ diam. Enlarged view of the diverticula, one of which is seen in Fig. 66, the other having been exposed by removing a thin section from the surface shown in Fig. 79. The inflammatory deposit in the subserosa has been dissected away.

New Growths.—Benign new growths of the large intestine may be adenomatous, lipomatous, fibromatous or polypoid in type, giving rise to obstruction or intussusception.

Malignant growths are adenocarcinomatous in type and are seen most frequently as circular constricting masses, much resembling the old-fashioned napkin-ring. This so-called "scirrhus" type does not involve the glands until a late stage of the disease. A second type in which cauliflower-like masses project into the lumen of the intestine, are

FIG. 81.—Peridiverticulitis. (20202) × ½ Diam. External view of necrotic portion of sigmoid resected at second stage of operation.

less common, but have a greater tendency to involve the lymphatics. Sarcoma is relatively uncommon, but does occur.

SURGICAL CONSIDERATIONS

The terminal 6 in. of the ileum and the cæcum have the same blood supply and lymphatic drainage through the ileocæcal vessels. For this reason, in all cases of malignant disease of the cæcum and cæcocolon, the appendix and terminal 6 in. of the ileum should be removed. Occasionally a lymphatic gland lies in the mesoappendix;

FIG. 82.—(44310) Autopsy series. A section of the jejunum showing multiple diverticula along the attachment of the mesentery and their relation to the blood-vessels.

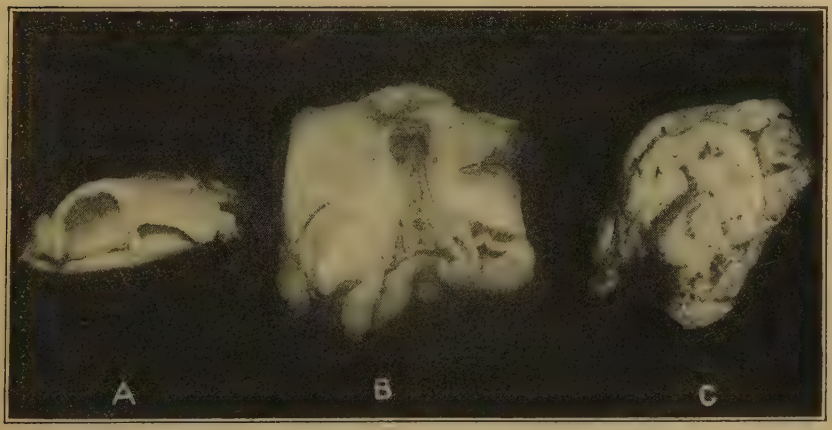

FIG. 83.—Special series. A (43987). A diverticulum from specimen in autopsy series (*no symptoms*). B(40506). A diverticulum from specimen in pathologic series (*peridiverticulitis*). C (43163). A diverticulum from specimen in pathologic series (*carcinoma; peridiverticulitis*).

if so, lymphatic drainage from the right ovary and tube may find its way into it through Clado's ligament.

The ascending colon is supplied by the right colic artery, a branch of the superior mesenteric, anastomosing below with the ileocolic and above with the branches of the middle colic. In about half the cases it arises with the ileocolic from a common trunk. The lymphatic drainage extends into the lymphatic glands at the base of the right colic artery and also in the ileocolic group. In carcinoma of the ascending colon it

FIG. 84.—(42987) Low-power photomicrograph. Section from (*A*) in Fig. 83.

is necessary to remove the cæcum and the terminal 6 in. of the ileum in order to secure the tributary lymph nodes.

The middle colic artery comes from the superior mesenteric, just below the pancreas and passes almost directly downward into the transverse mesocolon where it gives off large arterial arches to the right and left. The main arch passes to the left to anastomose with the left colic which arises from the inferior mesenteric.

While the anastomoses with the right and left colics suffice for the hepatic and splenic flexures respectively, in three cases out of five the

transverse colon itself will not be nourished in its whole extent if the middle colic vessels are ligated at their origin.[21] Injury to this vessel sometimes occurs in resection of the stomach for cancer and may cause gangrene of the transverse colon.

The splenic flexure of the colon has a reduplication of the peritoneum which is derived embryologically from the omentum and is sufficiently defined to be termed the "costocolic ligament." By dividing this

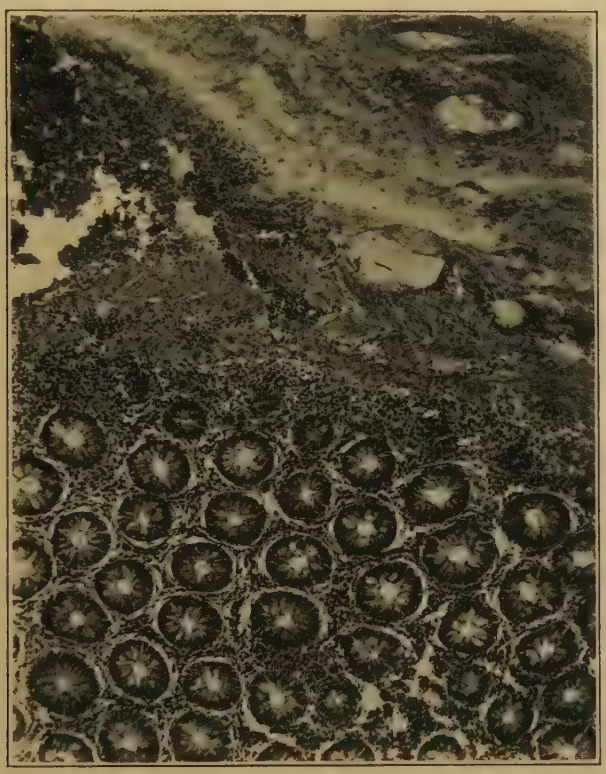

FIG. 85.—(40506) Low-power photomicrograph. Section from (*B*) in Fig. 83.

ligament, the splenic flexure is loosened from its deep situation and can be readily brought to the surface. The ligament has a small blood-vessel which should be tied. The hepatic flexure has not this source of retention, therefore, is more easily accessible than the splenic flexure. There is, however, often an extension to it of the duodenohepatic ligament.

The lymphatic drainage of the hepatic and splenic flexures as well as the transverse colon passes into the root of the transverse mesocolon. The lymph nodes are in close communication with the deep lymph chain

along the aorta and about the head of the pancreas and, in malignant disease, the accurate removal of the lymphatic-bearing tissues is correspondingly difficult.

The left colic artery supplies the descending colon, but its anastomosis with the middle colic above and the sigmoid below makes extensive resections in this vicinity relatively safe. Fortunately the lymphatic supply diminishes rapidly from the ileocæcal coil, and has reached its lowest ebb in the sigmoid. The very nature of the function of the colon, containing as it does virulent bacteria and toxic poisons, makes this lymphatic sparseness a necessity. Butlin[22] has shown that over 60 per cent. of the deaths from cancer of the colon take place from obstruction or other causes before there is general metastasis, and many times, if enlarged glands are present, they will be found inflammatory.

The tendency of the lymphatic drainage of the descending colon is toward the transverse mesocolon following the middle colic tributaries and toward the group of lymphatic vessels along the left colic to the base of the inferior mesenteric artery.

The sigmoid derives its blood supply from the sigmoidal artery (or arteries) which arises from the inferior mesenteric vessel and anastomoses freely above with the left colic, and below with the superior rectal. The lymphatic drainage follows the vessels, and as Moynihan[23] points out, the highest lymph node lies at the origin of the inferior mesenteric vessel. It would appear necessary, therefore, if we are to remove the tributary lymphatics in operating for carcinoma of the sigmoid, to resect extensively so as to remove the Moynihan gland with the mesentery, even though this may necessitate destruction of the inferior mesenteric vessel with its tributary intestine. Fortunately, these extensive resections are not often called for as the glands are not involved until a late period.

The relation of the anastomoses between the superior rectal blood-vessels and the lower sigmoid has been studied by Sudeck[24] and Archibald,[25] showing that ligature of the inferior mesenteric vessel above the sigmoid is safer than below this point so far as the integrity of the bowel is concerned. This is of minor importance since the vascularity of the sigmoid is well established by vessels lying close to the wall of the intestine and, if the circulation is interfered with, the intestine above is easily loosened and brought down to a well nourished point.

The terminal portion of the sigmoid, the so-called "first portion of the rectum," or better, the recto-sigmoid is supplied by the superior

rectal artery which communicates freely with the middle hemorrhoidal arteries. The lymphatic drainage follows the superior rectal vessel which is the direct continuation of the inferior mesenteric. To secure the highest lymph node, it may become necessary to ligate the inferior mesenteric vessel and remove the devitalized colon possibly almost to the splenic flexure. The rule, however, is that the primary lymphatics pass directly to the lumbar group just above the promontory of the sacrum. These extensive operations are based on theoretical rather than actual conditions.

In estimating the feasibility of removing malignant disease of the large intestine, examination of the liver for embolic carcinoma should not be forgotten. In our experience, hepatic secondaries have been a greater cause of contraindication to radical operation in mechanically removable tumors than inoperable glandular metastasis.

By rectal touch the peritoneal sac can be felt anteriorly at the recto-vesical fold. Carcinoma of any viscus in the peritoneal cavity may permit detachment of carcinomatous cells which gravitate into the cul-de-sac and graft on the adjacent sigmoid. This may be said to feel like a signet ring or, as Blumer[26] describes it "a rectal shelf," and gives rise to the characteristic nodules which indicate the nature of the primary and possibly unlocated disease.[27] In the female, the ovaries are often the objects of such grafting, producing cystic masses in the pelvis with great rapidity.

There are a number of fossæ in connection with the large intestine which may occasionally have surgical importance. They are due to faulty blending of the peritoneum with the large intestine, producing small pockets which extend up behind the bowel. There are several of these recesses about the cæcum in which the appendix is occasionally found.

The blending of the large intestine with the peritoneum is shown on the right side, the peritoneal sac being well developed before the cæcum and ascending colon reaches its normal position, which does not occur until at or near birth. The result is that the attachment of the head of the colon to the parietal peritoneum is of a veil-like nature, resembling adhesions, and may be mistaken for a diseased condition.

The entire large intestine is covered with a greater or less number of appendices epiploicæ, and in the obese individual these epiploic tags may reach considerable size. As a result of injury or local peritonitis they sometimes become attached to the parietes or neighboring structures, causing fixation of the intestine, or a band which may be the cause

of obstruction. Torsion may occur, with necrosis. We have met with two examples of this condition.

Preparation for Operation.—Perhaps no factor contributing to the dominance of the human race has proved of greater importance than the sterilization of food by cooking. While the secretions of the stomach outside the organ itself do not have marked bactericidal properties, it should not be forgotten that bacteria are vegetable organisms and that the digestive power of the stomach, with its living cells as well as secretions, acts to destroy the bulk of the microörganisms which have been introduced into it. Therefore, the contents of the duodenum and upper jejunum, as shown by Adami[28] and Cushing,[29] are relatively sterile. This is demonstrated clinically by the higher percentage of recoveries following perforations, gunshot injuries, etc., of the stomach, duodenum and jejunum, as contrasted with recoveries following perforations and injuries to the ileum and colon.

The ileum contains bacteria which rapidly increase in number as its lower segments are reached. The last 2 ft. of the ileum teems with virulent organisms. In the colon bacterial growth is marked and adds materially to the bulk of the stool. Hochenegg[30] points out that a liquid stool contains very active bacteria, especially of the colon group, and therefore catharsis should not immediately precede operation on the colon. The bowel should be thoroughly emptied 48 hours preceding operation, giving at least 24 hours for the intestine to become quiet. This is also advisable because of the greater ease of dealing mechanically with the bowel if its contents are semisolid rather than fluid.

Obstruction.—Taken as a whole, the most important factor in surgery of the large intestine is the question of obstruction. The mortality following necessary operations for this condition can be closely measured by its degree and acuteness. In some cases of tumor, unfortunately, the first important symptom is an attack of acute obstruction. This is particularly true of tumors of the sigmoid where the caliber of the intestine is more limited and the contents more solid in character. The obstruction interferes with the vitality of the distended intestine, renders it difficult to obtain proper asepsis during operation, and, if a resection is done, there may be considerable trouble in uniting the distended bowel to the collapsed segment. If the obstruction is acute the absorbed toxins depress the heart's action and the abdominal distention interferes with the action of the diaphragm; if chronic, the

interference with the progress of the food causes indigestion, nausea, gas and abdominal distention.

In suspected tumors of the large intestine, careful examination should be made to arrive at a diagnosis before the stage of obstruction is reached. In the majority of instances the patient will have had symptoms upon which an early diagnosis of beginning obstruction can be made. First, irregular bowel action, alternating constipation and diarrhœa with an unsatisfied feeling after stool, the movement failing to give complete relief. Second, cramps in the abdomen attended by borborygmus. The patient is nearly always able to locate the site of obstruction, since it will be found at the point where the internal pressure is most intense. Third, on palpation, the peculiar localized stiffening of the intestinal wall on the proximal side of the structure gives a tumor-like "feel" to the examining fingers which appears and disappears and is usually accompanied by gurgling of fluids and gases at the point of obstruction. Complete relaxation, without anæsthesia, can usually be obtained in the hot-water bath and a tumor, if present, can be detected. In low-lying tumors the sigmoidoscope may reach the growth and on several occasions, after a large soapy water enema I have found a sigmoidal tumor prolapsed into the rectum, so that it could be felt with the examining finger.

The danger of "drowning" from the regurgitation of intestinal contents during anæsthesia should not be forgotten, and every patient with obstruction should have the stomach emptied previous to operation. Operations during the stage of acute obstruction are best made under local anæsthesia with novocain. As a matter of fact, by careful attention to emptying the stomach and the use of saline enemata, a great many patients can be tided through a serious attack of obstruction and the operation later performed under more favorable conditions.

The Incision.—In proposed resection of the large intestine the incision should be placed to the inner side of the seat of the disease. If the diagnosis has not been established, it is best to make a median incision through which the hand can be used to explore the abdomen. A second working incision can then be made at the most convenient situation. The utmost care must be taken to prevent infection from intestinal contents. If the proximal gut is greatly distended it will be best to make a temporary incision into it at a point where the mesocolon is sufficiently long to allow its being drawn well out of the abdomen, and with a tube to empty the contained material after the method of Monks.[34] Treves[32] states that emptying the distended intestine at a point above the ob-

struction has reduced the mortality of operations one-half in acute conditions.

Mobilization.—The most important technical feature of the operation is mobilization of the large intestine. Because of its long mesentery, the blood, nerve and lymphatic supplies of the large intestine lie in the inner leaf of the mesentery and arise from the abdominal aorta and vena cava or in that vicinity. It is true that the outer leaf of the mesentery is exceedingly short, if not absent, in the ascending and descending colon and iliac sigmoid; but since the outer leaf contains no structures of importance it is only necessary to divide it, lift the colon from its bed and swing it on its inner leaf to the mid-line. Therefore, the *sine qua non* for efficient operation is to locate the lesion, divide the peritoneal reflection to the abdominal wall, which mobilizes the part and allows it to be completely drawn outside the abdomen where it can be adequately surrounded with aseptic pads for clean work. By holding the colon up to the light the blood-vessels in the inner leaf can be identified, caught, tied and divided. Moynihan[23] shows that even the descending colon can be mobilized in this way so that it can be anastomosed with the rectum or even brought down to the sphincter muscles. The transverse colon can readily be mobilized by dividing the gastrocolic omentum.

In separating the colon and ligating the blood-vessels there are some structures that must be identified. First, the *retroperitoneal duodenum*, a portion of which is bared in making a proper exposure of the ascending colon and the hepatic flexure. For this reason great care should be used in the ligation of the right colic and right branches of the middle colic vessels that the duodenum may not be injured or caught in the teeth of the forceps during operation. Second, the *ureters* must be identified and separated from adherent growths of the ileocæcal coil and ascending colon on the right side, from the descending colon and especially from the sigmoid on the left. It must not be forgotten that at a point just after the ureters cross the iliac vessels they are adherent to the peritoneum, and that, as the colon is mobilized and pushed toward the median line, the ureters may go with it. The left ureter will usually be carried with the sigmoid and should be identified and separated before the resection is commenced. Third, the *vasa deferentia* are closely associated with the lower sigmoid and rectum and while not so important, they should be protected from accidental injury.

The mobilization of the lower sigmoid is readily effected by incisions along the broad ligament just under the ovaries and tubes in the female

and at a like situation in the male. These are joined by a transverse incision at the bottom of Douglas' pouch. By identifying and separating the ureters this entire portion of the bowel can be lifted cleanly from the hollow of the sacrum. The superior rectal artery readily accompanies the intestine, but the middle sacral, which is usually present, and may be of considerable size, must be caught and tied.

In removing malignant growths of the large intestine, it will sometimes be found that a neighboring viscus has become involved and is attached to it. But if conditions are otherwise favorable, this should not be looked upon as a contraindication to operation. In such cases, we have resected portions of the small intestine, on several occasions resecting two or three entirely independent loops of small intestine, and after completing these resections, have removed the diseased colon with the fragments of small intestine attached.

Portions of the stomach which were attached to tumors of the transverse colon were removed on five occasions and on three occasions the bladder was involved, necessitating partial removal of its wall. One of these cases was most interesting because of the recovery of the patient (now over six years) after the removal of a considerable portion of the wall of the bladder, which was attached to and involved in a low-lying sigmoidal cancer as well as to a loop of ileum. Quite frequently, in the female, the ovaries, tubes and uterus become attached to sigmoidal growths. But little is added to the difficulties and dangers of the operation in removing these attached organs from before backward in one mass with the original growth.

Method of Anastomosis.—In our experience it has made comparatively little difference by what method the anastomosis was accomplished so long as the opening was large enough. Granting that end-to-end intestinal union is ideal, the results of the lateral, or end-to-side, have been functionally just as satisfactory. In union between the large and small intestine we have usually made the lateral operation by suture, leaving as small a pouch as possible beyond the opening. It seems to be quite immaterial whether the opening is made isoperistaltic or antiperistaltic so long as the intestines come together without angulation or traction. But in lateral union between two parts of the large intestine the resection should be isoperistaltic and the openings brought close to the stump-ends so as not to leave a distal pouch. Ileocolostomy is a safe method, where practical, because the contents of the ileum are fluid as compared with the solid or semisolid character of the contents of the colon. We are now using an end-to-end suture anasto-

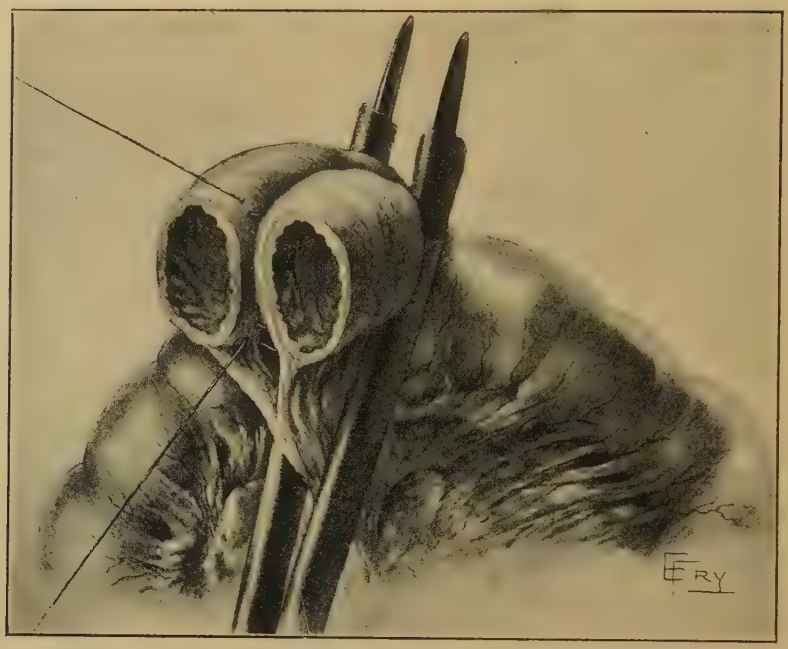

Fig. 86.

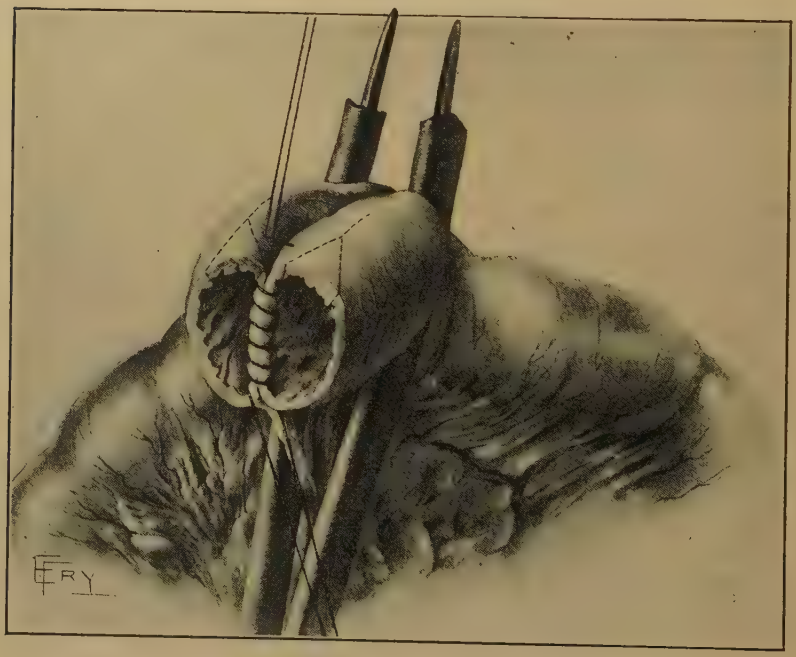

Fig. 87.

mosis after a method of C. H. Mayo's which can be described as consisting of weaving into the suture line on the anterior surface a plastic

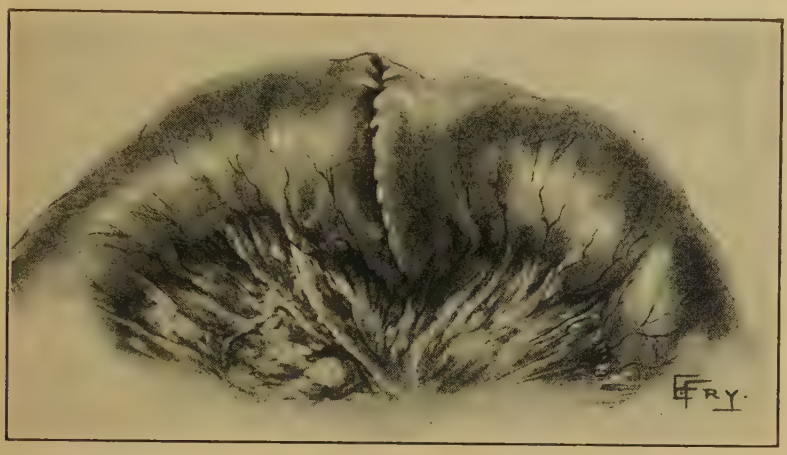

FIG. 88.

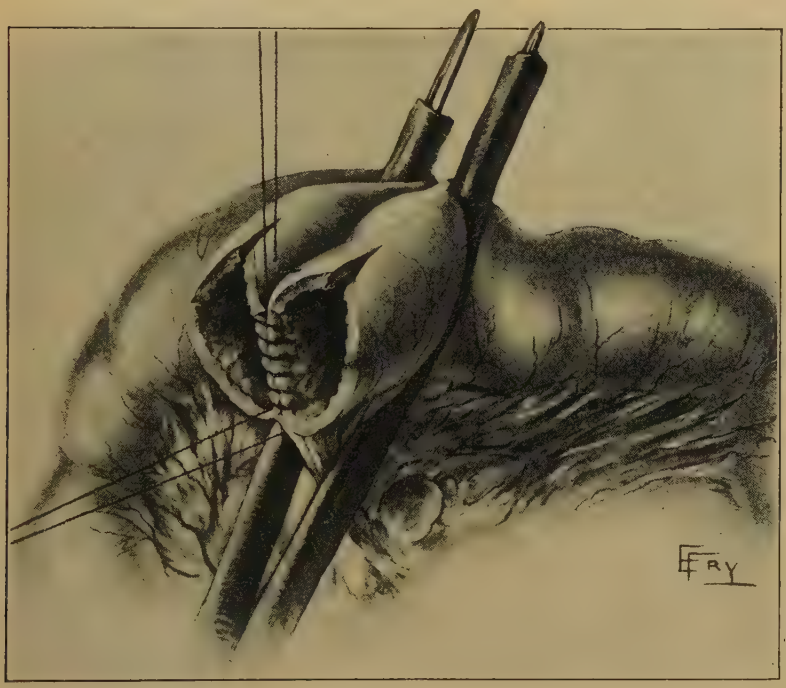

FIG. 89.

enlargement like a Heinecke-Mikulicz[33] pyloroplasty (Figs. 86 to 90).

In end-to-end resection of the large intestine it is rather necessary for a safe anastomosis, that at least one of the fragments should be well surrounded by peritoneum.

In all resections we use the two-row suture method with holding-clamps, and I would say again that the importance of the method of anastomosis, whether end-to-end, side-to-side or end-to-side, has been exaggerated. The more nearly the intestine approaches the normal, the better the prospects of end-to-end anastomosis, but with an intestine distended from obstruction, the less the mesenteric attachment is handled, the better. On several occasions I have had an opportunity

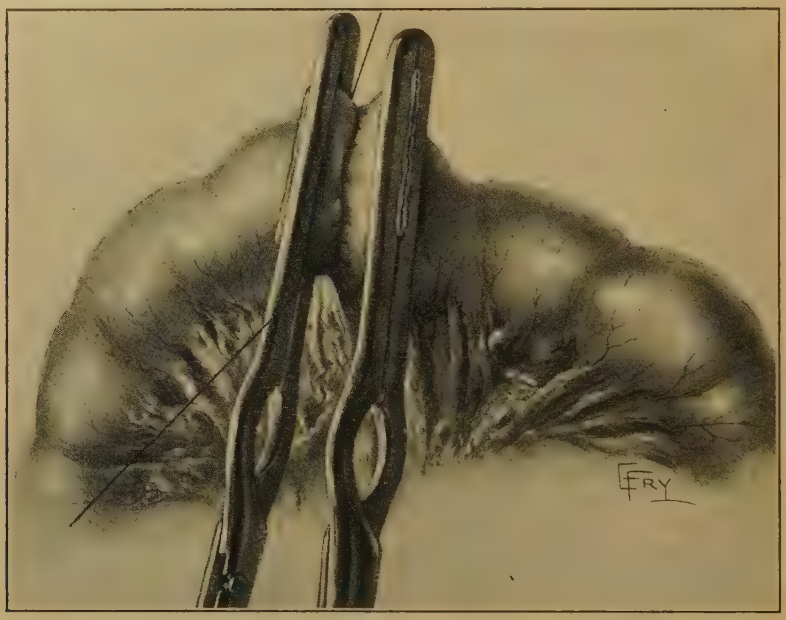

Fig. 90.

to observe the result of lateral anastomosis after one year or more, and only a small elbow, at most, marked the site of the union.

In making resections one is not always satisfied with the appearance of the bowel union, and fears leakage. We have in several instances fastened the anastomosed part to the peritoneum just underneath the incision, carrying down to it strips of rubber tissue so that if leakage occurred it could readily make its way to the surface, or the entire anastomosis can be suspended on a roll of rubber tissue in such manner that in a few hours it will become protected by adhesions to the peritoneum at the site of the abdominal wound. Gauze should not be

used for this purpose as it becomes entangled in the plastic lymph and is quite often followed by fistula.

In the large majority of resections of the descending colon and sigmoid, obstruction, infection and poor vascularity make the three-stage operation of Mikulicz[34] and Paul[35] the advisable procedure. At the first stage the tumor, with the mesentery and glands detached, is drawn out of the wound and the proximal and distal limbs united by sutures. The peritoneum is then united by a few interrupted sutures to the two

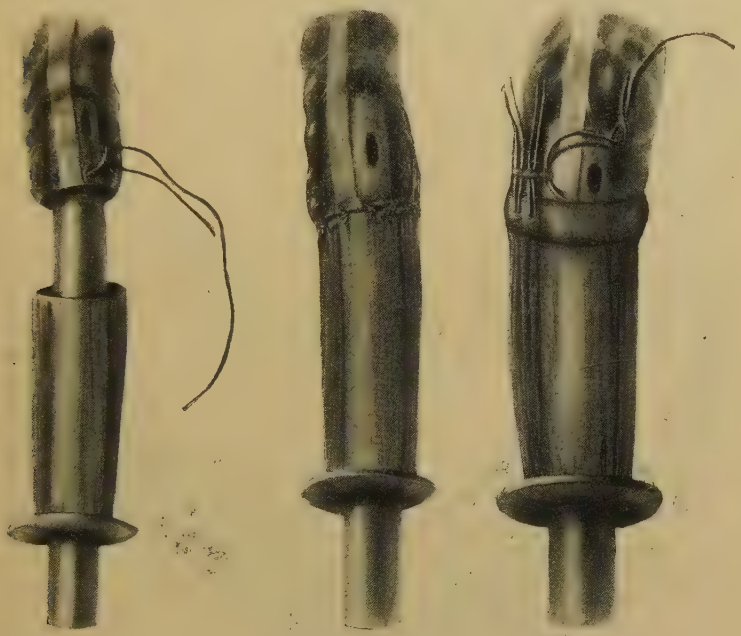

FIG. 91. FIG. 92. FIG. 93.

FIG. 91.—Showing tube introduced through rectum up into proximal sigmoid, and placing of catgut suture.

FIG. 92.—Showing tube used for bringing two ends into apposition and first row of sutures placed.

FIG. 93.—Showing intussusception accomplished and outer row of sutures placed.

limbs of the intestine on the inner aspect. If the symptoms of obstruction are acute, a small incision is made in the exposed mass proximal to the obstruction, and a rubber tube introduced through which the intestinal contents are carried into a receptacle, after the method of Paul. In the second stage, the tumor with the attached intestine is cut away on the third to the fifth day. Third stage. A heavy clamp is applied to the spur on the eighth to the twelfth day; this bites its way through, about four to six days later and, still later, the fistula can be

closed if it does not close itself. This method is tedious and the total convalescence is four to five weeks, but it is very safe and can be used when obstruction is present.

There is a group of low-lying sigmoidal tumors which are exceedingly difficult to reach and where a combined abdominal and perineal operation becomes necessary. In some cases, the whole of the rectum

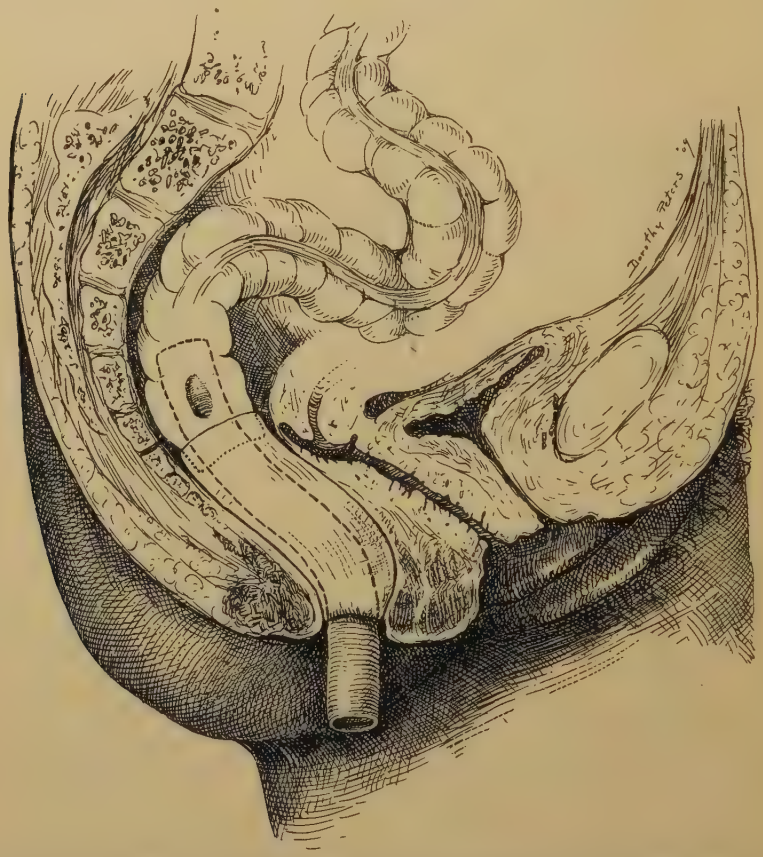

FIG. 94.—Profile drawing of median section of pelvis showing completed anastomosis.

must be removed and the sigmoid attached to the anal muscles, although occasionally the cut end can be united directly to the rectal stump. For making direct union between the sigmoid and rectum, Figs. 91 to 94, a ¾-in. rubber tube with an oblique end and lateral eye is passed from the anus upward into the sigmoid several inches above the union and fastened by a suture to the upper fragment, which greatly facilitates suturing. This tube is left from six to ten days to carry gas

and fæces past the suture line.[36] In two cases of this type we closed the end of the rectum completely, leaving it as a pouch, and made a permanent left inguinal colostomy.

The abdomino-perineal operation for low-lying sigmoidal growths has been unusually fatal in fleshy males. On several occasions, in males weighing 200 pounds or more, the tumor was removed by the posterior route through an incision which passed from the anus upward along the left side of the sacrum, excising the coccyx and the fourth and fifth sacral vertebræ. The anus was closed with sutures and the rectum dissected out of its muscular bed. The peritoneum was opened and the entire rectum, with the fat and glands, lifted from the seminal vesicles, prostate and bladder. By lateral incisions the peritoneum was separated and the rectum, tumor and necessary amount of sigmoid amputated, the proximal end of the sigmoid carried down to and sutured into the muscles below. I have followed the recommendation of Peck[37] and left the distal end of the sigmoid closely sutured for four to seven days following operation. In this manner, complete primary union and a fair muscular control were obtained in four weeks. In some cases a sacral anus has been necessary.

One might suppose that complete obstruction of the intestinal stump for several days would lead to great distress if not to more serious effects on the patient. But if the bowel is allowed to become quiet for 24 hours before operation, and if during the time of complete obstruction the patient is kept on albumin water, strained soups, etc., the majority will go three or four days or more without much trouble. This effect can be continued for a day or two longer if the gas pressure becomes great, by putting a small cannula with a rubber tube attached into the projecting sigmoidal stump to carry off the gas and liquid fæces.

In several low-lying sigmoidal carcinomas in the female, when the patient was very much reduced from bleeding and sepsis, the Quenu-Tuttle[38] perineal resection of the entire rectum and lower sigmoid has been done with satisfaction.

I am well aware that the posterior and perineal routes are not to be recommended in operating for sigmoidal tumors, but in the obese and the very anæmic patients, operations of this type are well borne, and have, in our hands, been followed by complete recovery. Anyone using the method for the first time in these cases will be surprised at the ease and safety with which the rectum, sigmoid and tumor can be

removed, together with the fat and glands to a point as high as the promontory of the sacrum.

The results following resection of the large intestine for malignant disease are extraordinarily good. Probably not far from 50 per cent. of patients obtain a five-year cure. A number of patients operated on in our clinic have been cured for more than 10 years. At the present time, the mortality of the operation is probably not far from 10 per cent.

Palliative Operations.—In a certain number of cases, the affected bowel cannot be resected because of the involvement of structures which may not be safely removed. In these cases palliative measures become imperative.

Ileocolostomy, in which the ileum is joined to some part of the colon beyond the point of obstruction is frequently indicated. Lateral anastomosis between the small and large intestine is quite satisfactory in the proximal half of the large intestine, but an end-to-side should be used if the small intestine is joined to the sigmoid, as the little pouch which is left beyond the lateral anastomosis is liable to ulcerate.

Colostomy is often indicated for obstruction low down in the sigmoid. Two methods will be found satisfactory: the Lillienthal[39] method, in which the colostomy is made through the center of the left rectus muscle; and the Littlewood[40] method in which the opening is made through a straight muscle-splitting incision in the left loin, from a point near the tip of the twelfth rib to the crest of the ileum, just behind the anterior superior spine. The Littlewood operation places the opening in a situation in which any kind of retentive apparatus will hold its place, and the soiling does not involve the pudendal hair, which is difficult to cleanse and has a tendency to create foul odors.

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SECTION VI

INTESTINAL OBSTRUCTION

By

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The contents of the alimentary canal may become arrested in their passage through the bowel owing either to mechanical impediment, or to some imperfection in the action of the nervous and muscular apparatus—**mechanical and dynamic obstruction.**

Though in origin a case may be purely mechanical or purely dynamic, subsequently the two conditions frequently act together. Thus in mechanical obstruction when the tissues of the bowel are damaged by strangulation, meteorism, or inflammation, the adynamic influence comes into play, and in peritonitis, when distention and kinking occur, mechanical obstruction is superadded to paralysis.

Intestinal obstruction is not a disease *per se*, but is, or may be, the culminating effect of many very different abnormal conditions affecting the bowels. These include such dissimilar lesions as congenital abnormalities, traumatisms, hernia, volvulus, intussusception, embolism, cancer, tubercle, syphilis, colitis, peritonitis, etc. Most of these conditions produce effects other than obstruction, some of which are very dangerous, such as gangrene and toxæmia. Intestinal obstruction is, therefore, not only very variable in its origin, but is frequently overshadowed by complications developing during its course.

While the symptoms entirely referable to obstruction are frequently by no means the most serious of those presented in a clinical picture, they themselves vary considerably in accordance with the anatomical site where the arrest occurs. Experimental work has shown that a high duodenal obstruction in dogs is fatal by toxæmia in a very few days (Draper-Maury, Mayo Clinics, 1910); while a low obstruction in the ileum is fatal only after weeks, and then by inanition. There is abundant clinical evidence pointing in the same direction, and it may safely be said that, other things being equal, the higher up the obstruction is placed the more acute and dangerous will the symptoms be.

The causes of intestinal obstruction are too numerous, the course is too varied, and the anatomical situations too widely separated to render it possible to frame an accurate definition sufficiently comprehensive to include all cases. It is best to put the cases in groups, and to consider each group separately. They may be classified according to (*A*) the character of the obstruction; or (*B*) the lesion causing the obstruction.

	(*A*)	(*B*)
Dynamic obstruction.....	Enterospasm.	Paresis, paralysis, and tonic spasm.
	Enteroparalysis.	Congenital abnormalities.
Mechanical obstruction.....	Stenosis.	Hernia.
	Constriction.	Peritoneal and other bands.
	Occlusion.	Intussusception.
	Obturation.	Volvulus.
	Strangulation.	Cicatrical and malignant stricture.
		Impactions.
		Embolism and thrombosis.
		Kinks and compression.

Enterospasm is a tonic contraction of both circular and longitudinal fibers at some portion or portions of the intestine, accompanied by a colicky pain, and reducing those portions temporarily to the condition of a firm fleshy cord.

Enteroparalysis or paresis, is present in all cases in which the vitality of the bowel is seriously lowered, or in which it is over-distended, as in strangulation, embolism of the mesenteric artery, septic peritonitis, and all conditions of meteorism.

Stenosis is the term applied to narrowing of the caliber of the bowel due to changes in its wall, chiefly malignant, tuberculous and other ulcerations.

Constriction refers to compression from without.

Occlusion is limited to complete closure.

Obturation signifies internal obstruction, as by a gall-stone or other foreign body.

Strangulation occurs when constriction is sufficient, not only to obstruct the bowel, but to arrest the circulation and paralyze the nerves.

The second table will be the more convenient one to follow in describing the different forms of intestinal obstruction.

Paresis and Other Forms of Dynamic Obstruction.—Reflex stimulation of the inhibitory nerves of the intestinal wall may give rise to a condition the equivalent of obstruction. Such reflex paresis may be originated by various painful lesions. Cases have been recorded associated with acute orchitis, or following surgical operations, abdominal

injuries, renal and biliary colic, perforations into the peritoneum, and septic peritonitis.

Over-distention of bowel causes paralysis. This is an important condition since it enters into so many cases of obstruction. Until a local meteorism develops, the prospect for surgical treatment is generally favorable; but when once a general meteorism is established, all cases are dangerous. Over-distended bowel does not respond to electrical stimulation (Nothnagel); but, unless long continued, the paralysis disappears on the distention being relieved.

Conditions gravely affecting the vitality of the intestinal wall, such as embolism of the arteries, strangulation, or very excessive distention, cause complete paralysis.

Reflex inhibition has been called into account for many cases in which no other apparent cause was discovered for an obstruction. In some of these the condition may have been enterospasm rather than enteroparalysis. A patient, aged forty-eight, with well-defined symptoms of obstruction, including fæcal vomiting, showed, on exploration, no bowel lesion, but she had suffered from biliary colic. It might be assumed that this was a case of reflex paralysis, yet she vomited a turpentine enema shortly after it was given, indicating considerable intestinal activity, though abnormal. This patient recovered and had no further symptoms of obstruction. There can be no doubt that reflex paresis often takes part, and sometimes an important part in the development of obstruction. Toxic matters in the peritoneal cavity after the first momentary stimulation exert a reflex paralyzing influence upon the muscular coats of the intestine. It is not easy to estimate how much of the ultimate condition is to be attributed to this, for associated with it is an interference with the absorption of gases and fluids resulting in over-distention, which is itself a sufficient cause for paresis and kinking. Over-distention and kinking of the tightly packed bowels are undoubtedly important factors in the lethal effect of septic peritonitis. At the same time it must be remembered that distention paralysis is of a temporary nature and usually disappears at once if the bowel be emptied, indicating that the loss of power and failure to respond to electrical stimulation are due to mechanical disadvantages rather than to true paralysis.

Reflex inhibition, toxic paresis, and the mechanical effect of meteorism and kinking are variable factors, often all combining to cause obstruction, especially in cases of septic peritonitis, and it is well for a surgeon not to be too much influenced by the dynamic as opposed to the

mechanical causes for such obstruction, as sometimes quite in the late stages life may yet be saved by giving mechanical relief, and so enabling nature's powers to deal with the toxæmia.

Congenital abnormalities as a source of obstruction may be divided into (*a*) those which act directly as in congenital stenosis and occlusion, and (*b*) those acting indirectly as in the case of a Meckel's diverticulum. The latter will be referred to under the titles of the immediate cause for the obstruction to which the congenital anomaly may have contributed, such as peritoneal bands, intussusception, etc. Of the former, malformations of the anorectal region are those which have the most practical importance, since all other kinds of congenital insufficiency of the bowel are rare, and usually not amenable to surgical treatment. These anorectal malformations are described on page 277; but in this connection it should be noted that permanent stenosis sometimes remains after sufficient relief has been given to bring the child along safely through the early years of life. The obstruction being so low down in the alimentary canal, and occurring at a period of life when during rapid growth the bowels may be expected to be most accommodating, it is not surprising that one occasionally finds the sigmoid developed into an immense fæcal reservoir. The most remarkable case of the kind I am acquainted with occurred in a lady whose rectum opened into the top of the vagina by a tight cicatricial orifice. She was seen at the age of 30 years, and was at that time only getting the bowels moved at intervals of three months, and had passed as long a time as five months without a motion of any kind. A more or less regular cycle had become established for after one of these periods of constipation violent diarrhœa would set in lasting about a fortnight and emptying the bowels. She then improved in health, developed a good appetite, and would feel quite well for some time without any more motion passing. Gradually the abdomen would swell up again until she was so full she could neither sit nor stand, and would sometimes be sick for a week before a passage was forced through the constriction and she obtained a fresh period of relief. A permanent iliac colotomy was done, and she has since remained in health and comfort. At the operation the sigmoid flexure was found to be enormously distended and formed a receptacle in which the fæces accumulated.

This is an exceptional case of prolonged constipation; but in chronic obstruction low down it is not a very rare thing to find that no evacuation has taken place for periods up to four weeks, and occasionally even longer.

Besides the anorectal region any other part of the alimentary canal may be the site of a congenital stenosis; but the duodenum just above the papilla of Vater, the ileum in the region of Meckel's diverticulum, and the ileocæcal region are the usual situations. The obstructions are usually diaphragmatic and complete, but are sometimes an atrophic condition of the bowel wall causing stenosis only. The former are almost necessarily fatal a few days after birth, but the latter may allow the liquid contents of the small intestine to pass with little or no sign of obstruction. It may be said that, with rare exceptions, the only congenital stenoses amenable to surgical treatment during the commencing weeks of life are those occurring in the pyloric and anorectal regions.

Hernia.—External hernia has already been treated elsewhere. The internal varieties are properly associated with the other internal forms of intestinal obstruction. Among these are often included certain kinds of false hernia, that is, protrusions of viscera through slits or openings or under bands in such manner that they may become incarcerated or strangulated, but in which no sac or any condition equivalent to a sac is present. These will be considered under other heads. The varieties in which a sac or a condition somewhat equivalent to a sac is present are (1) hernia through the foramen of Winslow; (2) diaphragmatic hernia; (3) retroperitoneal herniæ, duodenal, pericæcal and intersigmoid.

Hernia through the foramen of Winslow is scarcely a true hernia though it falls best into this group. Owing to undue size of the foramen, or unnatural length of the mesentery, or abnormal attachment of the mesocolon, bowel may find its way through this orifice into the lesser sac of the peritoneum and become strangulated there. Moynihan (Internal Hernia, 1906) considers an abnormality of the mesocolon essential, either an absence of secondary fusion of the ascending colon to the posterior abdominal wall or a common mesentery for the whole intestine.

The symptoms are those of acute obstruction with severe epigastric pain and a resonant tumor in the upper abdomen. Relief by operation has proved very difficult owing to the impossibility of enlarging the aperture by incision, since the hepatic artery, portal vein and common bile duct are contained in the anterior part of the constricting ring, while the foramen is bounded behind by the vena cava, above by the liver, and below by the duodenum. Moynihan suggests that the lesser sac should be opened through the gastrohepatic or gastrocolic omentum

and the distended coils of bowel emptied, when they might be withdrawn through the foramen of Winslow.

Diaphragmatic Hernia.—True hernia in which the viscera are surrounded by a sac is much less frequent than false, for whether the hernia results from congenital fissure or traumatism, the viscera are usually free in the pleural cavity, or rarely in the pericardium. Hernia on the left side is more than twice as frequent as on the right. Either the tendinous or muscular parts may yield to intra-abdominal pressure or be congenitally fissured or deficient. The œsophageal orifice, the posterior part between the spine and the last ribs, and in front near the ensiform cartilage are among the most usual situations to yield to pressure. Traumatisms are usually stab wounds or crushing injuries. The liver serves as a protective agent on the right side. The viscera usually entering into the hernia are the greater curvature of the stomach and the transverse colon with the omentum, sometimes small bowel or spleen, and more rarely the left kidney, left lobe of liver, or part of pancreas.

Diaphragmatic hernia, either congenital or acquired, may exist some time before symptoms of obstruction or strangulation supervene. In chronic cases the signs are those of pneumothorax, but varying in degree in accordance with the state of the abdominal viscera in the chest. Intestinal sounds are heard on auscultating the suspected area, and an X-ray examination after a bismuth meal will disclose the presence of stomach or bowel in their abnormal position. Accompanying these signs there is always more or less obstructive difficulty in the passage of food through the alimentary canal. Surgical treatment may be very difficult, for it may be necessary to open the thorax as well as the abdomen in order to reduce the hernia, and even when the viscera are easily reduced the closure of the aperture in the diaphragm is a delicate and difficult proceeding.

Duodenal Hernia.—This form of retroperitoneal hernia depends upon the presence of a peritoneal fossa at the duodeno-jejunal junction on the left side of the third lumbar vertebra. Many varieties have been described, but that known as left duodenal hernia is the most frequent. It originates in the paraduodenal fossa, or fossa of Landzert, a peritoneal pouch directed upward and to the left and having the inferior mesenteric vein in the fold encircling its orifice. Bowel engaged in this fossa may gradually distend the pouch until a sac of very large dimensions is attained, so large that it may contain the whole mass of the small intestine.

The only other variety of note is right duodenal hernia in which the

pouch is situated in the mesentery near the duodeno-jejunal junction, called by Moynihan the fossa of Waldeyer. The neck of the sac contains the superior mesenteric artery. This hernia develops to the right, that is, in the opposite direction to the more common kind of duodenal hernia.

Many of the cases have been recognized only post-mortem. The herniæ develop gradually and with only slight symptoms until chronic or acute obstruction supervenes, when a diagnosis may be possible owing to the presence of a tumor on the left or right side of the abdomen, which is resonant on percussion and may yield intestinal sounds on auscultation.

Pericæcal Hernia—This variety depends upon the presence of certain peritoneal pouches in the ileocæcal region, of which the ileoappendicular and the retrocolic fossæ are the most important.

The ileoappendicular fossa is formed by a peritoneal fold extending from the lower border of the last part of the ileum to the mesoappendix, producing a fossa bounded above by the ileum, in front and below by the fold, and behind by the mesoappendix.

The retrocolic fossa is seen when the cæcum is turned up. It lies behind the cæcum and ascending colon and extends upward for a variable distance. It is bounded on the outside by a peritoneal fold between the parietes and the cæcum—a cæcal ligament—and on the inside by a similar fold forming the iliac attachment of the mesentery. The appendix may be situated within the fossa.

Apart from strangulation and exploration it is very difficult to make a diagnosis of this lesion.

Intersigmoid Hernia.—When the sigmoid is raised there is found in the large majority of young subjects a distinct pouch beneath the mesentery over the common iliac artery. It extends upward like a glove finger sometimes as high as the level of the left kidney, and is due to imperfect physiological adhesion between the primitive mesocolon and the posterior parietal peritoneum (Toldt). Only a few cases of hernia into this pouch have been recorded.

Strangulation by Bands and Apertures.—The conditions present here are those of false internal hernia that is, the essential factors of hernia minus the sac. Cases may be grouped as follows: (1) fibrous bands due to old peritonitis; (2) abdominal organs such as omentum, appendix, or Fallopian tube, fixed at one end or part by peritoneal adhesions; (3) tumors with pedicles, usually ovarian or uterine; (4) congenital abnormalities such as Meckel's diverticulum; (5) congenital or other apertures in the mesentery or omentum.

A large majority of the peritoneal bands are secondary to appendicitis, salpingitis, and tuberculous glands. Notwithstanding that these causes are as much in evidence as ever, the adhesions due to them are becoming increasingly less as the value of prompt surgical treatment is more and more recognized, and already internal strangulation by peritoneal bands seems to be a diminishing evil. There is no practical distinction from our present point of view between fibrous bands pure and simple and those due to an adherent organ or pedicle, except that the latter have to be divided with caution, and appropriately treated.

When the band is short the bowel slipping under it usually becomes quickly strangulated with acute and urgent symptoms. When the band is long the bowel may be simply incarcerated, strangulation being absent or delayed, or a more complicated knotting may take place producing strangulation at once. Bowel which is incarcerated under a band sometimes becomes twisted as well.

Adhesions the result of peritonitis usually clear up remarkably after the source of the trouble has been removed; but when the irritation is persistent and long continued, as in recurring appendicitis, very firm adhesions develop, which are permanent.

Meckel's diverticulum is a persistent remnant of the vitelline duct containing, when patent, all the structures normal to the lower part of the small bowel, and frequently having a similar caliber. The vitelline duct opens into the free border of the ileum at a point which in the adult corresponds to a distance of about 12 to 20 in. above the ileocæcal valve. It should disappear between the sixth and seventh week of intra-uterine life. In the process of involution it changes from a tube to a cord, which in turn melts away leaving the bowel free from its connection with the umbilicus. When persistent, the diverticulum may remain in almost any stage of its involution: (1) as a complete tube from the umbilicus to the ileum, or as a complete cord; (2) as a tube opening into the ileum, but attached to the umbilicus by a cord; (3) as a tube, often bulbous, or a cord attached to the bowel, but not to the umbilicus; (4) the same, but the free end has contracted adhesions to some other structure.

The diverticulum is present in some form in nearly 2 per cent. of all people, being more common in males than females. It is most dangerous in the fourth variety, that is when a free diverticulum becomes reattached at its free end. Strangulation by a Meckel's diverticulum is more serious than by a fibrous band, both on account of its connection with the lumen of the bowel, and because it usually becomes gangrenous itself.

Apertures in the mesentery or omentum may be congenital or traumatic, or possibly acquired, for it is assumed that bowel may gradually press its way through a very thin part of the mesentery. The apertures are probably rare, for when accidentally made by a surgeon and left unclosed the small bowel seems to show a remarkable facility for finding them out and getting into trouble. The mesentery of the lower part of the ileum, which is longer and thinner than the rest, is the usual situation for strangulation through apertures. Omental cases are less common than one would have thought probable, when adherent tags producing bands are excluded. Operation wounds in the omentum and mesentery, such as those which may accompany gastroenterostomy, nephrectomy, etc., are well known as possible sources for internal strangulation.

Intussusception is a condition in which a portion of bowel is swallowed by the part immediately beyond it. Having once been fairly engulfed, the normal peristaltic movements tend to increase the displacement until the utmost possible degree of invagination is attained. In the small bowel the limit is reached sooner than in the large, where it is no uncommon event for the ileocæcal valve to present at the anus.

Although it is an almost constant experience to find that the invagination progresses downward in the normal direction of the intestinal contents, still a retrograde or upward invagination is occasionally met with, which may attain moderate but never great dimensions by reversed or retrograde peristalsis.

During the death agony small and usually multiple invaginations of the bowel are not unfrequent in children. They have no pathological significance, being due to perverted peristaltic contractions resulting from irregular stimulation of the controlling nervous centers just before death. They are called agonic intussusceptions, and are more frequently retrograde than downward.

Nothnagel describes the invaginations which are purely spasmodic and temporary as physiologic, and those which are permanent and progressive as pathologic. He demonstrates by experiment that circular spasm of the intestine may be the starting point of invagination, and assumes that such invagination may frequently occur under natural circumstances, and after slight symptoms of colic disappear again. Once an invagination has commenced, it is not difficult to understand why it should increase. The normal peristaltic contractions of the bowel tend to force it along. Moreover, it can hardly be assumed that a physiologic invagination is sufficient explanation for the whole

etiology of intussusception. Dissection of specimens has shown that there is usually some special structure at the apex of the entering layers. In most cases this is the ileocæcal valve. In others it has been a simple polypoid tumor, a prolapsed Meckel's or other diverticulum, a cancerous growth, an inflamed Peyer's patch, a tuberculous gland, an appendix, etc. In all cases there seems to be present some condition which might lead to a piece of gut being prolapsed into the bowel below it. This would excite the mucous membrane of the latter to stimulate the muscular coats to grasp and propel it onward as they would any other foreign body, and thus bring about the condition known as intussusception.

An intussusception usually consists of three layers of bowel; the entering and returning layers—the intussusceptum, and the ensheathing layer—the intussuscipiens. It increases ordinarily at the expense of the outer layer, which continues to propel the apex onward, drawing with it more and more of the entering and returning layers of the bowel. What was the apex to commence with, remains the apex throughout, except in the case of prolapse of the ileum through the ileocæcal valve when a greater or less amount of prolapse may occur before the cæcum is carried on with it. When an intussusception consists of more than three layers this is due to the fact that it as a whole becomes swallowed again, when of course there would be five layers instead of three. When this occurs it is usually an intussusception of the ileum which has undergone reinvagination at the ileocæcal valve; but this may occur elsewhere, and the process may possibly be repeated, giving rise to additional layers.

The effect of intussusception is to drag severely on the mesentery which is drawn into the bowel. A minor result of this is that the tumor has a curved shape like a sausage. The more important effects are upon the circulation and the lumen of the bowel. The former soon becomes seriously impeded, and in acute cases ultimately arrested; while the latter tends equally to pass on from stenosis to occlusion. In regard to the circulation, the drag on the mesentery first creates an increasing stasis in the veins. The mucous membrane of the intussusceptum becomes intensely congested, and blood and mucus are exuded from its surface into the bowel. Then œdema and ecchymosis into the submucous and muscular coats follow causing great swelling, which increases both the pressure on the vessels and the stenosis. Ultimately in acute cases the circulation is entirely arrested, the bowel is occluded, and the tissues become gangrenous. Peritonitis is set up, at first affecting only the intussusception and causing adhesions; but if generalized, a fatal issue is precipitated. The lethal changes in the

bowel are chiefly limited to the intussusceptum, the ensheathing layer being under quite different conditions, and suffering less in consequence. Without operation most cases are fatal, and even with operation, unless undertaken at an early stage while the tumor is reducible, there must necessarily be a high mortality owing to the extensive gangrene and the susceptibility of young children to shock. It sometimes happens, though very rarely, that plastic peritonitis seals the intussusceptum and the intussuscipiens at the neck of the intussusception. The former may then ulcerate through at the line of demarcation and be discharged per anum, sometimes entirely everted, that is, with the mucous membrane outside. When this occurs it is due to the fact that the entering layer has separated before the returning layer was free, and in its flaccid state it is easily everted by the *vis a tergo* of the onward rush of pent-up fæcal matter above it. Such cases of natural cure are recorded in which no subsequent stenosis has occurred. They are, however, very rare, and should not be taken into consideration in reference to treatment.

After the establishment of an intussusception a case may follow different courses. (1) There are reasons for believing that it may sometimes disengage itself, but there is no evidence that this is a common occurrence. (2) Having attained a certain, usually considerable, limit without arresting the circulation or causing complete stenosis, it may go no further and is then called chronic intussusception. (3) Owing to some accidental circumstance further interference with the circulation or lumen of the bowel may convert a chronic into an acute case. (4) Or it may be, as it usually is, acute throughout, following the course previously indicated.

Acute intussusception is almost entirely an accident of early childhood, most of the cases occurring in children under one year of age, and nearly all under ten. Chronic intussuception may occur at any age; but most of the few cases which are met with in adults are of the chronic type, at any rate at first, and sometimes remain chronic for a year or more until they come under a surgeon's hands. They usually commence at the ileocæcal valve, which is then not rarely the seat of a malignant growth. The prolapse progresses about as far as the splenic flexure, where the apex may be recognized as an easily palpable movable tumor. The whole mass is really immense, but the rest is more concealed in the right loin and under the liver, and so is less striking and noticeable than the apex. Peristaltic waves in the hypertrophied sheath are often very marked.

Intussusception may occur in almost any part of the bowel, and is

called in accordance with its origin enteric, enterocolic, or colic. The enteric variety is mostly limited to the ileum. The colic may involve any part of the colon. The enterocolic is of three varieties; ileocæcal, ileocolic, and cæcal. In ileocæcal cases the ileocæcal valve is the apex of the intussusception. In ileocolic the ileum has first been prolapsed into the cæcum through the valve and forms the apex. When the origin is in the cæcum itself the fundus of the cæcum with the appendix is the apex, and the valve is on one side. Ileocæcal intussusception is the commonest variety, and many include with it the ileocolic and cæcal cases, which are only subvarieties. Next in frequency to these is the enteric form, and lastly come the pure colic cases as the most rare.

Volvulus is the term used to designate twisting or knotting of the bowels. It is met with in two well-recognized forms: (1) that in which the bowel is twisted on its mesenteric axis; (2) that in which a loop of free bowel is twisted round a more fixed base which is frequently a primary axial volvulus. The first variety is ordinarily called twisting, and the second is sometimes distinguished as knotting, though it is better to restrict the latter term to the more complicated knots in which bowel is occasionally involved.

Volvulus is not a common cause of obstruction, and of the cases which occur the great majority, probably more than two-thirds, involve the sigmoid flexure. The next most frequent site is the ileum, and then the ileocæcal junction. Twists in the colon and upper part of the small bowel are very rare. A long loose mesentery seems to be an essential factor in the production of volvulus, so that when it is met with in the colon, a more or less abnormal mesocolon is necessary. Twists are also seen in the omentum, especially when it has been moulded into a fusiform mass in a hernial sac.

The twisting of the sigmoid flexure is usually from left to right, so that the rectum passes behind the sigmoid portion of the bowel. The conditions which bring it about are somewhat obscure, but an abnormally long mesocolon and a voluminous coil of bowel are always present. There is also usually a history of previous attacks of severe constipation, and as the immediate cause an accident or strain is common. All this helps to explain how a long, loose, heavily loaded fold of bowel may tumble over in such a position as to undergo a half rotation on its mesenteric axis; but such a position is not uncommon, at any rate in the case of a loose pelvic colon, as is well known to every surgeon familiar with inguinal colotomy. The point that needs clearing up is why a volvulus, once established, should go on twisting until the turns are so tight that

ordinary force could twist it no tighter. Moreover, a not uncommon "knotting" is due to a coil or coils of small bowel being swept up by the twisting sigmoid and knotted round the base of the primary volvulus. There is evidently some mechanical force which comes into play after the first half turn has been accomplished, just as there is in intussusception. One sees half turns which produce no symptoms, and which may be of daily occurrence; half turns which evidently run to the verge of danger, since they set up acute attacks of flatulent constipation; half turns which become chronically fixed, and are a permanent source of chronic obstruction; and finally, half turns which go on to complete and multiple turns, giving rise to paresis, hemorrhagic effusion, meteorism, and gangrene of the entire mass of bowel involved.

Bowel is not the only organ that goes on twisting when the first half turn has been accidentally accomplished. I have seen, and no doubt others have, two and three complete turns in cases of torsion of the testicle, and even more in ovarian tumors. No one can suppose that any accident could at one strain turn a testicle round three times; therefore, it must have gone on turning after the accident had produced sufficient torsion to interfere with the circulation and set up spasmodic contractions in the associated muscular fibers. It has also been observed that when a sigmoid volvulus has been punctured, emptied, and reduced, it has twisted again as more gas entered from above and redistended it. It, therefore, seems probable that in the case of twisted bowel, violent peristalsis, venous turgescence, and meteorism in some way combine to keep up the revolutions until the part can revolve no longer. Similar conditions are present in bowel nipped by a band, and seem to offer the only explanation for the twisting frequently met with under such circumstances. As soon as the circulation is completely arrested, and the bowel becomes gangrenous, it is probable that no further rotation would take place, but the meteorism is continued until the utmost limit is reached.

In no other condition does local meteorism attain the dimensions arrived at in volvulus of the sigmoid. In a chronic case met with post-mortem many years ago the pressure of the summit of the flatulent sigmoid (a chronic half turn) against the left lobe of the liver had reduced the entire lobe to a leaflet about $\frac{1}{16}$ in. in thickness (specimens B12 and A264, Liverpool University Museum). Such meteorism as this is due to egress being more impeded than ingress; but when the torsion is complete, and the circulation is arrested, it is due to the formation of gases in the strangulated bowel with cessation of absorption, and still

more to the accumulation of blood and serum in both the bowel and the bowel wall. The sigmoid, after a volvulus has fully developed, forms a tremendously heavy, black mass, distended with enough saneous, tarry fluid to half fill an ordinary toilet basin.

When small bowel is knotted round a twisted sigmoid, and I have seen a very big mass so knotted, it seems to me that the twisting of the sigmoid is probably the mechanical cause of it in most instances. Still the standing part of the bowel, to use a nautical term, need not be a twist, but anything which like a large tuberculous gland may give a fixed character to a portion of the mesentery. I believe strangulation to be more probable and more severe in the former instance than the latter, but have not seen sufficient cases to prove this. When a twist is originated by a foreign body like a gall-stone in the bowel it is usually of the ordinary axial type.

However, volvulus occurs, or whatever part of the bowel it involves, in the great majority of cases obstructive symptoms are soon followed by those of strangulation and gangrene, and the only prospect of relief is a sufficiently early operation. As in other forms of obstruction the higher it is in the alimentary canal, and the greater the amount of bowel involved, the more acute and dangerous will the symptoms be. A considerable gangrene of the sigmoid is far more recoverable than a considerable gangrene of the small intestine.

Cicatricial stenosis is usually due to healed or partly healed ulcers of the bowel, and occasionally to traumatisms. These fibrous contractions are most frequent in the rectum. They are also not uncommon in the duodenum, where they are secondary to peptic ulceration. In the rest of the small bowel tuberculosis is the only frequent ulcerative condition leading up to stricture. In the colon, stercoral or decubital and tuberculous ulcers are the usual cause of simple chronic stricture, though the former is more frequently met with as a source of perforation than occlusion. Extensive ulcerations in the rectum and colon are sometimes tuberculous. In past years probably many of those occurring in the rectum were classed as syphilitic, and still in the colon it is not always easy, even with our modern aids of diagnosis, to distinguish between tuberculous and some other forms of ulcerative colitis. In either situation such ulcers may certainly heal and cause fibrous contractions, either single or more commonly multiple. Apart from this type of stricture, especially in the ileocæcal region, tuberculosis may give rise to stenosis from the massive deposit in the wall of the bowel. Dysenteric ulcera-

tion is said not to cause stricture, a statement which should be accepted with some reservation. Typhoid ulcers certainly heal almost invariably without effective contraction. Syphilitic ulceration is very rare above the pelvic colon, and is chiefly restricted to women, in whom it is the most frequent source of fibrous stricture of the rectum. When all the foregoing varieties of ulceration are excluded there still remain a few exceptional cases, which may be difficult of explanation. The following is an example. A lady, aged 25 years, was attacked with pain and tenderness in the epigastrium, constant vomiting, and had a febrile temperature. Her doctor regarded it as a case of acute gastritis, and in two or three weeks she recovered. Subsequently the patient suffered from frequent attacks of constipation with painful colic, which culminated after seven months in complete obstruction, with meteorism and fæcal vomiting. At this stage an operation was undertaken, and the cause of the obstruction was found to be a fibrous contraction in the transverse colon. The contraction measured 1½ in. in length and 3/16 in. in diameter, was smooth, and cord-like, and without any external adhesions. A lateral anastomosis was done, and she was soon quite well again. In this case an acute destruction of a short segment of the bowel occurred, such as might have resulted from an embolism or thrombosis.

The traumatisms which cause stricture are injuries by indirect violence in which the bowel has been very severely contused but not ruptured, recoverable strangulations, the swallowing of corrosive substances and such rare occurrences as the spontaneous cure of an intussusception. These are much less common sources of occlusion than might very well be expected, when we take into consideration the frequency with which some of the primary conditions are met.

It must be borne in mind that some forms of malignant stricture are so small and contractile as to be practically indistinguishable from cicatricial stenosis without microscopical investigation. Such scirrhus-like ring strictures are found in the small as well as in the large intestine.

Malignant stenosis is a well-recognized and frequent cause of stricture of the bowel. It may attack any part of the canal, but there are certain situations in which it is common, and others in which it is very rare. Cancer here as elsewhere is prone to commence in parts subjected to chronic irritation, and also in "rests" of tissue derived from obliterated developmental structures.

In the small intestine, cancer is met with in the upper part of the duodenum, and the lower part of the ileum. Between these situations it

is extremely rare. I have only once seen a growth in the jejunum, and in that cases there was one, and only one other tumor in the body, a growth of about equal size in the pelvic colon. The jejunal tumor set up the symptoms, but there was nothing to show whether it was primary, equal, or secondary to that in the colon. Cancer of the duodenum almost invariably, perhaps always, commences either in the scars or sores of simple ulcers; or at the orifice of the common bile duct. In the lower ileum it seems not improbable that its site is influenced by the presence of some remnant of the vitelline duct.

In the large bowel, cancer is most common in the rectum and pelvic colon where the fæces are hard, and stercoral ulcers occur. It is also frequent in the cæcum, and at the ileocæcal valve. No part of the colon is free from it, but at least four-fifths of the whole number of cases are met with in the situations mentioned.

Malignant growths of the bowel may be placed in four groups:

1. Sarcoma. A small round-celled growth of malignant type attacking the outer coats of the bowel, and producing a fusiform tumor surrounding the canal and constricting it without ulceration. Also a rare melanotic form of sarcoma attacking the rectum near the anus.

2. Fungating carcinoma. A long columnar-celled growth of less marked malignancy than the other types. It commences as a villous-like tumor, but as it progresses it infiltrates the submucous structures and ulcerates. Ultimately a large foul ulcerating growth is produced, surrounding the bowel and causing more or less stenosis. It bleeds readily, and discharges mucus. Early secondary metastases are uncommon, though the neighboring lymphatic glands usually appear much enlarged owing to septic infection. Its favorite situation is the cæcum, but it attacks all parts of the large bowel. This fungating or villous type of cancer is one of the most favorable malignant tumors for surgical treatment.

3. Scirrhus or ring stricture. This is also a columnar-celled growth, though this feature is less constant and marked than in the foregoing type. It ulcerates early and contracts, causing a marked stenosis, though the tumor has but little bulk. It is more penetrating and infective than the fungating growth, but not so malignant as the next variety. Ring strictures need a wide removal together with the adjacent mesentery and lymphatic glands. Their favorite situation is the sigmoid region, but they may be seen in any other part of the large bowel, and sometimes in the lower ileum.

4. Colloid cancer. This forms a large, hard tumor ulcerated on the

bowel side, the ulcer having a smooth surface, and an abrupt hard edge. It is the most malignant of the bowel cancers, infects the lymphatic vessels and glands early, and is liable to attack the peritoneum, spreading far and wide. It is most frequent in the rectum.

All these growths cause stenosis, but occlusion is much more common in ring strictures than in the other varieties, though even in these cases the final complete obstruction is generally brought about suddenly by some undigested food matter plugging the narrowed lumen of the canal. All except sarcoma ulcerate early and mucus and visible or occult blood may be found in the motions. The fungating growths are most prone to bleed, and to set up fermentative changes in the bowel with pyrexia. Quite young people are subject to alimentary cancer, especially in the rectum where growths are not uncommon between the ages of 20 and 25 years. Under 20 they are rare, and also between 25 and 35. After this there is an increasing frequency until 60, when the rate gradually declines. In young subjects the growth is usually of the fungating type, sometimes colloid, and rarely scirrhus. In middle aged people all kinds are met with. Above 60 colloids growths are rare, and ring strictures rather more frequent, but at all periods fortunately the favorable fungating type is that which is most often seen. Sarcoma of the bowel is very uncommon.

Impactions.—(*Internal obturation*).—This condition results from (1) fæcal impaction; (2) foreign bodies; (3) enteroliths; (4) gall-stones.

Fæcal Impactions (*coproliths*).—It is doubtful if simple fæcal accumulation can be regarded as a sufficient cause for intestinal obstruction. The conditions under which a collection of hard fæcal masses may occur in the pelvic colon are the exact reverse of those associated with genuine obstruction, for such masses are the outcome of bowel atony and feeble muscular development, and their presence in the bowel is possible only during the continuance of such conditions. When these are overcome by purgatives, tonics, massage, enemata, etc., the masses are passed, and the supposed obstruction vanishes. An impaction which actually arrests the onward passage of the bowel contents, bringing about a complete and genuine block, is itself at once a sufficient cause to stimulate an energetic peristalsis such as would promptly remove an uncomplicated fæcal accumulation. But if the ultimate block is brought about by such complications as kinking, torsion, or the presence of a stricture below the coproliths, though the peristalsis would be stimulated in the same way relief might not follow, and a true obstruction would be established. This, however, is not obturation by

fæcal impaction, but an obstruction by kinking, twisting, or stenosis, excited or complicated by the presence of fæcal accumulation. Probably the abdomen has been opened many times for simple constipation with so-called fæcal impactions. The operation has been a mistake, and the best recoveries will have been those cases in which it was promptly concluded without any attempt to treat the impactions surgically. When kink, twist, or stricture is present, of course it would receive its appropriate treatment.

Foreign bodies which obstruct the bowel are of two kinds: either they are an accumulation of small particles concreted into a large mass; or, like coins, bone, tooth-plates, nails, knives, etc., are of sufficient size when swallowed to become arrested in their passage through the alimentary canal. Among the former may be mentioned masses which usually accumulate in the pelvic colon or cæcum, and consist of fæcal matter mixed with oat husks, fruit stones, insoluble magnesia salts, or similar indigestible substances; and secondly materials which felt themselves into a ball, such as various fibers, string, hair, and feathers. The felting usually takes place in the stomach where the bezoar remains, and then are many examples of enormous masses of hair and string which have been taken from the stomachs of women, mostly post-mortem. Some lesser balls of similar texture have, however, been found in the small bowel, having escaped from the stomach, or been felted in the latter situation. In either case obturation is almost inevitable sooner or later with the urgent symptoms of a high obstruction.

Obstruction by the larger foreign bodies is easy to understand. They may be arrested anywhere from the pharynx to the anus. After the œsophagus the next most frequent site is just above the internal sphincter. The stomach, the ileum, and the ileocæcal valve are other fairly common situations. This type of foreign body is frequently angular with sharp corners or points, and in such the danger of perforation is greater than that of obstruction. When a stricture is present a smooth body may be retained above it for years. I once found above a rectal stricture a sovereign, which had been swallowed 11 years previously. It was supposed to have been stolen, and its long retention must have been a great disappointment to the thief.

Enteroliths are concretions derived from substances formed in the alimentary canal, and are essentially of the same nature as gall-stones or urinary calculi. They usually form in diverticula, and the concretions so common in the appendix are typical of the larger masses rarely found in the bowel. Appendix concretions are generally soft, and their

basis is an intestinal soap (O. T. Williams, Liverpool Medico-Chir. Journal, 1908). Occasionally they are hard and calcareous, consisting then chiefly of salts—carbonates and phosphates of ammonia, lime, and magnesia. In the bowel the soft concretions are less pure than in the appendix, being mixed with more fæculent matter. I have only once seen obturation caused by such a concretion. The case was that of a lady, aged 40, who was suddenly attacked with urgent symptoms of obstruction, soon accompanied by fæcal vomiting. On operating, an enterolith, measuring 1½ in. in diameter, was found in the ileum, completely blocking it. Unfortunately it was believed to be a gall-stone, so no search was made for a diverticulum; but it seems very improbable that such a large concretion could have been formed in the lumen of the bowel without creating sufficient symptoms to have attracted attention. It was analyzed by O. T. Williams, and was found to consist of concentric rings of intestinal soap entangling fæcal débris and surrounding a central nucleus of vegetable matter.

Gall-stones.—Cholecystitis is a frequent result of the presence of gall-stones in the gall-bladder, and it is not a very uncommon experience when operating, to find that suppuration has taken place, or even that the gall-bladder has perforated, and the stones and pus are lying in a recess walled off from the general cavity of the peritoneum by adherent omentum and bowel. The symptoms accompanying such a condition are frequently serious and acute, but by no means always so, and I have several times opened such a collection of stones and pus when there was very little reason to expect it. Gall-stones of moderate size may in this way enter the bowel more frequently than we are aware of, for it is a remarkable fact that, in those cases in which obstruction is due to a large impacted stone, the preliminary symptoms often pass entirely unnoticed. Six cases of gall-stone obturation, five females and one male, have come under my personal observation, and no history of jaundice or biliary colic was given in any one of them. All the stones were very large, and were arrested in the jejunum or ileum. None reached the ileocæcal valve. In all, complete obturation was present. In another case, a male, smaller stones were arrested in the duodenum owing to previous ulceration and stricture. Stones passing by the common duct must always cause jaundice, and are very rarely of sufficient size to produce intestinal obstruction. Those which are large enough to obstruct the bowel usually ulcerate through the neck of the gall-bladder into the duodenum. Some ulcerate into the colon, and may be passed unnoticed if not arrested at the internal sphincter.

It would seem that ulceration into the bowel is the probable issue in cases in which very large gall-stones are present, since it is quite rare to find stones of sufficient size to cause intestinal obstruction in the gall-bladder. Indeed one more frequently operates for gall-stone obturation when the stones are from 1 to 1½ in. in diameter than for gall-bladder trouble.

Kinking.—The importance of kinking of the bowels is sometimes exaggerated. It is not a primary cause of obstruction, but when associated with atony it no doubt encourages stasis, and when secondary to paresis and meteorism in peritonitis it is an active and persistent cause for the continuance of obstruction. Bowel in a normal tonic condition is capable of overcoming an excessive amount of kinking, as is often seen in patients who have suffered from chronic peritonitis, and whose bowels are matted and adherent in all directions, but still act well. At the same time in the presence of atony and proptosis much slighter kinks appear to lead to a harmful stasis, though never to actual obstruction. On the other hand, it is evident that in many cases of acute peritonitis it is the kinks which are responsible for the maintenance of occlusion. Often if a tube be inserted into the bowel and one or two coils emptied, the rest will become active, the kinking disappears, and the issue of the case is completely changed.

Compression.—Bowel occasionally suffers from compression other than that which has been described under the heads of bands, strangulation, volvulus, etc., compression due to tumors or enlarged organs. It is surprising to find how accommodating the intestines are in the presence of large ovarian tumors, a gravid uterus, retroperitoneal sarcoma, hydronephrosis, and other similar conditions, which must exercise a good deal of intra-abdominal pressure. As a matter of fact in only quite exceptional cases is obstruction produced, and then it seems almost necessary that the bowel should be in a position in which escape from the pressure is impossible, as in the case of the rectum, which sometimes becomes squeezed between a pelvic tumor and the bone.

Embolic Obstruction.—Embolism of the superior mesenteric artery is a rare event, always of the most serious import. The embolon is usually derived from the heart, and if a considerable branch or the main trunk is blocked, the intestine suddenly becomes bloodless, and is thrown into tonic spasm causing severe colic, which may be accompanied by reflex vomiting and a violent movement of the bowels. Soon venous hyperemia appears, and the condition of embolic infarction

results with frequently hemorrhagic stools. The affected intestine necroses. If the case is not fatal from shock, as it usually is, within the first 48 hours, peritonitis develops, which is rarely if ever remediable. The subjects of this embolic trouble are usually unfavorable for surgical operation, and cases will sometimes pass undiagnosed as examples of inoperable "acute abdomen."

I have seen only two cases of extensive embolism of the superior mesenteric artery. Both died in less than 24 hours. The first was a Coroner's case, a young servant girl, and the diagnosis was made at the post-mortem. The other occurred in a lady, aged 66, in whom the diagnosis was corroborated by a later blocking of the right radial artery.

The Symptoms of Intestinal Obstruction.—The pathology of the various forms of intestinal obstruction is so different, that it follows there must be much complexity in the symptoms, and many difficulties in making an accurate and definite diagnosis. In dealing with this subject it seems well that we should first recognize the essential factors, then discuss the leading signs and symptoms, and finally group together those indications which point to special lesions.

The primary essential factors in creating the symptoms are: (1) the arrest of the fæcal flow along the alimentary canal; (2) the arrest of the circulation in the affected part of the bowel; (3) the effect upon the nervous mechanism.

An uncomplicated arrest of the passage of the contents of the alimentary canal occurs in cases of stenosis and obturation. The symptoms induced by such arrest are greatly influenced by the point at which it takes place, and by the completeness and suddenness with which it is brought about. The first matter has already received attention on page 219, and at the bedside it will always be found that the high occlusions set up more urgent symptoms, and are much more rapidly fatal if unrelieved, than those which occur lower in the canal.

A gradual and imperfect occlusion means chronic obstruction in which the bowel has time to make some effort to accommodate itself to the increasing difficulty offered by a contracting stenosis. It becomes hypertrophied above the stricture, and the peristalsis is increased, giving rise to flatulent colic with borborygmus, the contracting and relaxing coils of bowel being evident to sight and touch, and frequently clearly indicating the site of the obstruction.

Complete obstruction is necessarily sudden in its onset, though chronic stenosis may have pre-existed. A primarily complete obstruc-

tion is the more serious condition, as a previous stenosis prepares the way and trains the bowel to fight. The more sudden the onset, the sooner the bowel yields and becomes dilated and paralyzed above the stricture. Whenever the block is absolute, a sequence occurs of pain, nausea, belching and vomiting, increasing in severity. When the obstruction is high up, as it usually is in gall-stone obturation, the vomiting is urgent from the first, and soon becomes stercoraceous; but this change is more and more delayed the lower it is placed. In the jejunum or upper ileum a fæcal odor in the vomited matter may be expected about the second day, but in the colon it may be delayed for weeks, and then occur only just before death, or even not at all. In the high obstructions the vomit first consists of stomach contents, is then bilious, and subsequently a thin, yellow, foul fluid, becoming more brown and fæculent. In the low obstructions the vomiting is less urgent, and changes from simple mucus to green fluid mixed with food substances, and becoming feculent with time.

The only toxæmia in uncomplicated obstruction is auto-intoxication, which is much less serious than the toxæmia of gangrene or peritonitis. There is no elevation of temperature, no profound shock, and operation if timely gives immediate and pronounced relief.

An uncomplicated arrest of circulation is seen in embolism and thrombosis of the superior mesenteric artery, in which, though the circumstances differ much from strangulation, the effects in many ways are quite similar. After the first depletion due to blocking of the artery the venous system becomes intensely engorged. Blood is extravasated into the tissues of the bowel, and escapes from the surface of the mucous membrane. In volvulus, and strangulation by bands, and hernial openings, these effects are localized to the constricted portion of the bowel; but in embolism and intussusception, blood is free in the alimentary canal, and usually passes per anum.

Arrest of the circulation of course involves death of the bowel, which is associated with shock and toxæmia, and later with septic peritonitis. Here again proximity to the upper end of the canal and suddenness in onset have the same baneful influence on the symptoms. The amount of bowel involved is also of the greatest importance.

The effect upon the nervous mechanism. Any sudden accident to the alimentary canal produces an immediate effect upon the nervous system. Apart from the pain there is at once a local reflex influence upon the stomach and bowels, accounting for the frequent initial vomiting and evacuation; and a further reflex influence upon the general

nervous system, which in the worst cases produces that terrible picture of collapse with which we are all so familiar in severe strangulations, the cold skin, pinched features, sunken eyes, blue lips and extremities, feeble pulse, and profuse perspiration. An important later effect is the paresis or paralysis of the bowel wall, which is so often a source of the greatest difficulty in treatment.

The nervous phenomena are secondary to the primary conditions acting mechanically on the lumen and circulation of the bowel, and are influenced chiefly by these, but also partly by individual susceptibility.

The Leading Signs and Symptoms of Intestinal Obstruction.—*Constipation* (*coprostasis*).—The one essential feature in all cases is constipation, complete or incomplete. In stenosis it is usually a gradually increasing condition, frequently an alternation of constipation and diarrhœa, and it is sometimes the diarrhœa due to augmented peristalsis which first attracts the patient's attention. The degree of constipation bears no direct relation to the caliber of the stricture, being almost more influenced by the natural habit of the patient's bowels. In those who normally have easy evacuations, and bowels easily stimulated to looseness, the early stages of a stricture pass unnoticed; while in others with a naturally sluggish habit increased constipation is soon evident.

Constipation which is the result of stasis has sometimes to be distinguished from that due to stenosis or occlusion, and the distinction is not often difficult. The history, the constitutional condition, and the constantly torpid state of the bowels in stasis is in marked contrast to the resentment always excited in the alimentary canal by direct opposition. Even when the occlusion results from a fæcal impaction, secondary to stasis, the onset of the genuine block is announced by an increased activity in the bowel endeavoring to overcome the obstruction.

Constipation is complete in strangulation by bands, hernial orifices, and volvulus, and in all effective internal obturations, except that a reflex emptying of the large bowel is not uncommon at the commencement of the trouble. The higher up the obstruction, the more motion there is likely to be below it, and one must not be misled because in some cases a fair amount of fæcal matter can be washed out of the colon. When an obstruction is overcome, thin yellow or brown motion escapes. Hard, dry, scyballous motion comes from below the seat of mischief.

Intermittent constipation is met with in stenosis, simple or malignant, in partial volvulus, and in incarcerations which are not strangu-

lated. The attacks are accompanied by loss of appetite, nausea, flatulent colic with borborygmus, and uncomfortable distention of the abdomen. They pass off with complete relief as the obstruction yields.

In intussusception, motion continues to be passed in chronic cases mixed with a good deal of glairy mucus. In acute cases there is no motion or flatus, but blood and mucus are characteristic. In embolism copious blood stools are frequent.

In septic peritonitis constipation is variable. The prognosis is much influenced by its presence or absence.

Vomiting is another almost constant symptom. It is of three kinds, reflex, regurgitant, and toxic.

Reflex vomiting is most noticeable in cases with a sudden onset accompanied by severe pain and acute strangulation. The vomit consists of food or frothy mucus.

Regurgitant vomiting is due to a backward flow of the contents of the obstructed alimentary canal. After the stomach has been emptied, and when nothing more is swallowed, copious vomiting may still continue, the fluid being supplied either by a return flow from the bowel, or by a secretion from the gastric mucous membrane. When the fluid is derived from the bowel it is at first bilious, but shortly stercoraceous; there has been much discussion as to the mechanism by which this effect is produced. In the first place there is no doubt that an impaction as high as the middle of the jejunum is followed by vomiting, the smell and character of which soon becomes markedly fæculent. The more difficult point to decide is in what way the reversed current is established and maintained. Above an obstruction, fluid and gas collect and distend the bowel for a limited but increasing distance. When the impediment is near the stomach it is easy to understand that by mechanical means alone, the bowel might fill and overflow backward into the stomach; also that normal peristalsis acting violently above a stricture would tend to create a flow backward in the direction of least resistance. But it is difficult to see how these forces could keep up stercoraceous vomiting, when, as often happens, the obstruction is low, and many feet of the upper jejunum are practically empty, or at any rate not distended. There remains antiperistalsis. Antiperistalsis is a well-recognized physiological phenomenon. It is capable of producing a retrograde intussusception, and of carrying fæcal matter up from the colon, for there are well-authenticated cases of the vomiting of solid fæces. It is also capable of carrying an enema right through the alimentary canal, for I once saw a patient vomit gruel and turpentine

which had just previously been injected into the rectum. It seems to me, therefore, that the time honored view of stercoraceous vomiting by reversed peristalsis has much to recommend it.

Septic vomiting complicates cases of strangulation and peritonitis. It is due to the toxæmia associated with these conditions, which excites severe irritation of the gastric mucous membrane, causing an excessive watery secretion. This toxic vomiting materially assists in depleting the circulatory system, and hastening a fatal collapse though its harmful effect is to some extent met by saline instillation.

Pain is the initial symptom in all acute cases of obstruction, and runs intermittently through the chronic cases. It subsides only when the paralyzed bowel has ceased to fight, or the inflamed peritoneum is shielded by fluid. The pain comes chiefly from two sources; irritation of the nerves of the peritoneum, and muscular spasm of the bowel. Intense primary pain is characteristic of all perforations, and especially of the allied condition acute pancreatitis; of all sudden severe strangulations which rapidly kill the bowel, and of embolic infarction; also of all displacements which involve a tight drag on any of the viscera.

Peritoneal irritation is accompanied by cutaneous hyperæsthesia over the affected area, and tenderness, often exquisite, on pressure. The primary effect of this peritoneal irritation is seen in reflex vomiting, as has been mentioned. A further reflex effect is the tonic spasm of the muscles of the abdominal parietes, guarding the tender part, and creating the board-like abdomen, which is such an important indication of deep mischief.

Pain due to muscular spasm of the bowel is present in most cases of obstruction. It is of the nature of colic with intermissions and exacerbations, and is an excellent sign for the surgeon, for of course it subsides with paresis, and when that happens the best time for surgical help has gone by. The character of the pain varies a good deal with the circumstances of each case. A foreign body may excite tonic spasm, keeping up pain all the time. Strong bowel will undergo strong contractions, which will be so much the more painful if they are not effective.

Meteorism is local or general. It is local in a portion of bowel which is strangulated, notably in a volvulus, and in a variable length of bowel above an occlusion. It is general in the widespread paresis of septic peritonitis. Meteroism has a very adverse effect on cases of obstruction, for it greatly increases the difficulties for surgical operations and surgical relief. It is both a result and a cause of paralysis of the

bowel, and it maintains obstruction by continued paralysis and kinking after the primary cause has been removed. It raises the intra-abdominal pressure to such an extent as to seriously impede both respiration and circulation, and is frequently the direct cause of a fatal issue. The worst meteorism occurs in sigmoid volvulus and other obstructions of the large bowel, and in peritonitis.

Collapse is the outcome of shock, or toxæmia, or both combined. Sudden severe injury, such as a traumatism, embolism, or strangulation of bowel, especially of much bowel, causes serious shock. So does the toxæmia of extensive gangrene, as in volvulus, and of general septic peritonitis.

Peristalsis.—As a rule visible peristalsis means obstruction. The exceptions are limited to patients who have very thin, delicate, abdominal parietes, in whom normal peristalsis is sometimes visible. Visible peristalsis is not necessarily painful, but when the contractions are violent, and especially if also ineffective, the pain is sharp and cutting. Contractions stimulated by a foreign body in the bowels, such as a gall-stone or by an intussusception, are always painful. Occlusion stimulates peristalsis, which tends to increase until meteorism supervenes and paralyzes the bowel. Antiperistalsis is also probably a common accompaniment of occlusion.

Hiccough is due to a reflex irritation of the phrenic nerves, and is sometimes very distressing. It is most marked in peritonitis, especially when the inflammation involves the diaphragmatic region.

Thirst and anuria are natural results of vomiting and sweating, but since the introduction of rectal saline instillation they have ceased to exercise the adverse influence on the course of a case that they formally possessed.

Tumor.—In certain cases a tumor can be felt, and when that is so we have an additional advantage for diagnosis. Spasm of the muscles of the abdominal parietes, distention of the abdomen, tenderness, and the circumstance of the tumor being in a difficult situation to palpate or too nearly of the consistence of the surrounding bowel often make it impossible to feel a tumor through the abdominal wall, although it is at once detected when the abdomen is opened. An intussusception may usually be felt on careful palpation, either in the cæcal or the splenic region. Malignant strictures also can generally be felt under favorable conditions, especially in the cæcum or sigmoid. Internal herniæ, and volvulus can sometimes be felt, and so may gall-stones, and other foreign substances; but on the whole it is only in malignant

stenosis and intussusception that we are much influenced in our diagnosis by failing to detect anything in the shape of a tumor.

Ribbon or Other Moulded Fæces.—Alteration in the form of the fæces voided is of doubtful value as an indication of stricture, except when the stricture is very low in the rectum. Motion which is soft enough to pass through a very narrow constriction is easily remoulded in the rectum. If retained long enough to be dehydrated it may escape as normally formed motion; but if passed at once as it comes down from the stricture, it is very likely to take a ribbon or pipe-stem shape, which is really moulded by the internal sphincter.

Diagnosis.—Cases of obstruction may be grouped as acute febrile, acute mechanical and chronic.

The acute febrile cases include all those which are associated with septic peritonitis, such as perforative and gangrenous appendicitis, perforated gastric, duodenal, stercoral, and malignant ulcers, acute pancreatitis, etc. They constitute the group known as the "acute abdomen," and are characterized by sudden onset, severe pain and a tonic fixation of the abdominal muscles. Reflex vomiting is common. On examination there is marked hyperæsthesia, especially over the site of the primary mischief, and tenderness on pressure, as well as the board-like resistance of the parietes; a rising pulse, only slightly quickened at first, but steadily increasing in rapidity; temperature above normal except quite at the first, and soon rising to upward of 100°. The abdomen is usually flat, at the onset, but soon becomes distended, and later there will probably be evidence of fluid in the peritoneal cavity. The respiration is thoracic. The expression is anxious. The bowels may be moved once spontaneously, but later there is paresis with constipation and an increasing meteorism. The amount of shock varies with the character and area of the peritoneal irritation. The more intense the irritation, and the more widespread it is, the deeper the resulting collapse. More detailed symptoms of these affections will be given in the chapters specially devoted to them.

The acute mechanical obstructions include all strangulations, hernia, bands, intussusception, volvulus, etc., and impactions, and embolism. Strangulation in proportion to the amount of bowel involved, and its proximity to the upper end of the alimentary canal, and the suddenness and completeness of the strangulation is accompanied by intense pain, and profound shock, with a more or less retracted but not hard abdomen, an anxious expressions, feeble pulse, and cold perspiration. Later there is colic, vomiting, eventually stercoraceous,

toxæmia, peritonitis, and meteorism, according to the course of the case. Bands, large torsions, and embolism have usually the most sudden and serious onset of this group. Intussusception develops less acutely. The patients are nearly always very young. It is accompanied by considerable pain of a colicky nature with tenesmus and the passage of blood and mucus per anum. A tumor is usually felt, either in the cæcal region or near the splenic flexure, or, when advanced, in the rectum.

Volvulus of the small bowel presents the picture of a very serious strangulation with pain, shock, vomiting and complete obstruction. Sometimes the hard mass of strangulated bowel can be felt and is of course very tender to the touch. The abdomen is full, and meteorism early. Sigmoid volvulus presupposes a large pelvic colon with a long mesentery, and frequently there is a history of previous attacks of severe constipation. The collapse develops more slowly than in the case of the small bowel, but meteorism is early and intense, impeding the heart's action and respiration. The bowel will not retain even a small enema, and the upward drag on the rectum may be recognizable per anum. Toxæmia and peritonitis follow gangrene about the third or fourth day.

In gall-stone impactions the preliminary gall-bladder symptoms generally pass unnoticed. The onset is usually sudden and painful; vomiting is distressing from the first, and soon becomes stercoraceous. The abdomen is empty, frequently hollow. Considering the distressing nature of the vomiting, and the character of the vomit, the patient is less collapsed than would be expected. The condition indicates complete obstruction without the grave depressing effect of strangulation and gangrene. The early stercoraceous vomiting, the flat or hollow abdomen, together with the absence of severe shock are the keynote. Impactions lower down in the small bowel may be less sudden in onset, but as soon as the obstruction is complete similar symptoms will develop. Obturations of the large bowel nearly always have a history of previous stenosis, colic is more marked, and vomiting less urgent, and the stercoral change more delayed. The abdomen is always more or less distended.

Embolism of the superior mesenteric artery, if extensive, is accompanied by great abdominal pain and early collapse. Blood is often passed by the bowel, or constipation is complete. There may be evidence of other infarcts. Most cases are fatal before peritonitis has time to develop.

Chronic Obstructions.—It may be very difficult to make a correct diagnosis between the different forms of chronic obstruction. In all, muscular hypertrophy and visible peristalsis is to be expected and is of great assistance in determining the site of the stenosis. When the bowel is active and contracting, the transverse ridges of small bowel can usually be definitely distinguished from the circumferential course of the large intestine; but at a later stage, when obstruction is advanced and meteorism has abolished peristalsis, it is often difficult to distinguish between large and small, except that a distended cæcum may generally be mapped out owing to its great size and more or less spherical outline, affording the important information as to whether relief is or is not possible by colotomy. In the earlier stages an X-ray examination after a bismuth meal is most useful in determining the site of the stricture; but in the later stages of course this method cannot be employed. In malignant cases the age of the patient, the detection of a lump, and the presence of mucus and blood, visible or occult, in the motions generally enable a correct diagnosis to be made.

An incomplete volvulus as a source of obstruction is rare, and its diagnosis when it does occur may easily be missed. When present it is almost sure to be in the sigmoid region, and causes recurring attacks of constipation with colic, which are overcome with difficulty. When they are overcome the patient is perfectly well until the next attack. In all such cases there is a very real danger that at any moment a half turn may become a whole turn, and instead of an attack of constipation the patient is suddenly afflicted with one of the most dangerous forms of internal strangulation. Before general meteorism develops, a twisted sigmoid may be felt as a hard swelling extending upward diagonally from the left iliac region.

Chronic intussusception in the adult should not be difficult to diagnose yet I believe most surgeons have made the diagnosis on the operating table. I have seen three cases, and this occurred to me in the first two. The patients present a history of chronic constipation with definite onset, there are colicky pains in the abdomen, with mucous stools, and a large tumor very easily palpated. The lump usually shows up in the splenic region, and perhaps owing to the general tumefaction of the abdomen it may escape notice though equally large on the right side. Still, on careful examination, the large curved mass will be detected, extending from the right iliac fossa to the left hypochondriac region, in which peristaltic contractions occur. When the shape and position of the tumor are recognized, and colic, visible peristalsis,

tenesmus, and mucous stools are present, the diagnosis is easy. Incarcerations, contractions, mattings, incomplete obturation from impactions, and some other chronic cases can often only be accurately diagnosed by collateral circumstances, such as a previous history of appendicitis, tuberculous peritonitis, hernia, or some other indication pointing to a probable cause for the present trouble. Whether the diagnosis is definite or not, whenever there are distinct symptoms of chronic obstruction an examintion into the cause by exploration is thoroughly warranted, as it is in such cases that we are able to afford the most satisfactory relief.

The Treatment of Intestinal Obstruction.—Prompt surgical treatment is that which is essential for intestinal obstruction. The more acute the obstruction, the more urgent the operation. Today one does not need to labor this point. It is accepted, not only by surgeons, but by the whole profession; yet its acceptance was a matter of time, too much time. In my earliest surgical experiences, 1878, the mortality after operations for acute intestinal obstruction was practically 100 per cent. Even in 1896 Sir Frederick Treves wrote, "The mortality of the operation for acute intestinal obstruction is very high, possibly 75 per cent." (A system of surgery edited by F. Treves, Vol. II, 1896.) An ideal mortality would not exceed 5 per cent. The difference between the two is owing to *delay*. There should never be unnecessary delay after the diagnosis has been made.

There are two conditions which may be present in any case of obstruction when it comes under observation and which, if present, should receive immediate attention; collapse, and fæcal vomiting.

The collapse is primarily due to shock resulting from bowel injury, and secondarily and chiefly to the loss of water by vomiting and sweating, and to toxæmia. It is best treated by saline injections, usually given per rectum, and which may if thought advisable contain an ounce of brandy. Such injections with warmth and care will often considerably improve the pulse in the necessary interval between seeing the patient and operating.

Whenever fæcal vomiting is present the stomach should be washed out by a soft tube and funnel with normal salt solution. It is generally recommended that this should be done before the patient is anæsthetized on account of the danger of inspiring vomited matter. In robust patients this is quite right, but in those who are delicate and exhausted some ether may be inhaled first without any appreciable risk.

Cases of obstruction which are acute in origin and febrile in type are almost invariably associated with peritonitis. In such, both the peritonitis and the obstruction require surgical treatment; but since this will be described in a different section it will not be fully dealt with here.

The Treatment of the Acute Febrile Cases of Obstruction.—The indications for treating acute peritonitis are: (1) to remove the cause; (2) to treat the peritoneum; (3) to treat the toxæmia; (4) to treat the obstruction.

Septic peritonitis 20 years ago was almost uniformly fatal. Step by step certain essentials of treatment have been learned. The first is that the source of contamination must, whenever at all possible, be removed. When this is a perforated or gangrenous appendix the operation is straightforward. In perforated gastric ulcer closure by suture and infolding as advocated by Moynihan is the rule. Occasionally excision may be wise. In malignant ulcers or any others which can be neither closed nor excised the best way of preserving the peritoneum from further infection is to drain the perforation with a rubber tube, pack round it with gauze, and wall off by suturing the omentum about the danger zone. In perforated duodenal ulcer the usual practice is to close and infold; but if the patient's condition admits I like to pucker the pylorus with a purse-string suture, and do a posterior gastroenterostomy. In perforated stercoral ulcer the peritonitis, though no doubt very infective, is often limited to the lower abdomen. Drainage, suture, and the removal of any foreign body are indicated, with probably colotomy. An essential part of the latter is an efficient spur to make it certain that no more fæcal matter will pass down to the perforated ulcer until it has entirely healed. Perforations of malignant ulcers in the rectum or colon are in my experience very fatal. Excision of the growth is never possible. Drainage, with suture and packing, and colotomy, or short-circuiting may be attempted when feasible. In acute pancreatitis the infective inflammation becomes complicated with auto-digestion, hemorrhage, and the escape of pancreatic juice into the tissues and peritoneal cavity causing a destructive fat necrosis and peritonitis. Unless the escape of this corrosive digestive fluid can be diverted from the peritoneum the case will be rapidly fatal. Sometimes early drainage of the gall-bladder saves the situation, but after full development, the only chance lies in thorough drainage of the pancreatic region, of course with the former unless prohibited by the patient's condition. The

best drainage is posterior, and the next an anterior drain through the gastrohepatic omentum. The best treatment of all is to use both methods of drainage. The adhesions which are usually present between the omentum and the anterior abdominal wall should be encouraged as a means of limiting the mischief; but if there is free fluid in the peritoneal cavity a tube should be put into Douglas's pouch above the pubes.

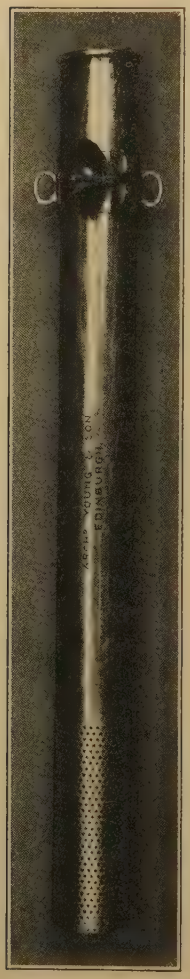

Fig. 95.—(*Paul.*)

The treatment of the peritoneum itself in septic peritonitis has been the subject of much discussion. It needs cleansing and draining. The cleansing may be carefully effected with dry swabs when there are no coarse particles or any very toxic matters free in the cavity. But when stomach contents, fæces, or foul discharges are present I prefer to wash out the pelvic region with a double-channeled tube. The question of drainage is an important one. In its absence one has to rely upon the soundness of the operation employed to remedy the primary lesion, and upon the capacity of the individual to resist further infection. It is, therefore, a matter for an experienced judgment to decide when it may be omitted, and it is safer if in doubt to drain. The old plan of inserting three or four drainage tubes into the loins and other parts has been properly abandoned. One now drains the primary seat of mischief in some cases, such as a foul appendix, though not a well-closed gastric or duodenal ulcer; but always the pelvis in all cases in which there is free septic fluid in the peritoneal cavity, the pelvic drain being assisted by adopting the "Fowler position" for the patient. The best type of tube for the pelvis is a long wide silver tube with a movable collar and minute perforations (Fig. 95). Both omentum and gut may pass through the ordinary perforations of glass tubes, and become strangulated. The tube should reach to the bottom of Douglas's pouch, and be retained by a sufficiently loose suture to permit of some movement. It is drained by a gauze wick, frequently changed as long as the discharge is septic. As soon as the bulk of the discharge is over, usually four or five days, a rubber tube

is introduced through it, and the silver one withdrawn. The rubber is then shortened day by day until it is discarded.

The toxæmia is treated by saline instillation and purgatives. If a purgative like calomel is effective, the patient with ordinary surgical care will get well. As a rule it is not effective, and saline medicines like sulphate of soda are vomited. Eserin sulphate in doses of from $\frac{1}{100}$ to $\frac{1}{50}$ of a grain was the first improvement upon the more ordinary stimulants of the alimentary canal, and possessed the immense advantage of being a subcutaneous remedy; but it has been eclipsed by pituitrin. This substance in simple paresis acts like a miracle, especially in feeble subjects after a rather severe abdominal operation; but in advanced septic peritonitis it unfortunately, like every other purge, frequently fails. It must be used before distention and kinking have been thoroughly established if it is to be relied upon. Saline instillation, which is of so much value for other reasons, helps in this matter too, and when the body is well saturated with fluid again, it may be possible to get the bowels to act. Normal salt solution is introduced in various ways. In cases in which there is but little anxiety it may be injected into the rectum by a soft tube and funnel every few hours; but in the more serious cases Murphy's method of drop by drop instillation into the rectum is universally regarded as the most comfortable, convenient, and satisfactory. The only drawback it possesses is that in the absence of trained assistance the rectum often becomes over-loaded, and the fluid runs out instead of being absorbed. When such assistance is not available I find Barnard's tubes in the subcutaneous tissue of the thighs more certain and effective. It is true the subcutaneous method is more painful, and sometimes causes a slough, but the introduction of the fluid is essential, and must be effected at any cost. In peritonitis originated by appendicitis, the appendix stump has sometimes been used successfully for the saline instillation. This plan has its advantages, and should be borne in mind. In the absence of saline injections or instillations the body becomes so depleted of fluid by vomiting and sweating as to render the elimination of the poison by purging and free peritoneal discharge impossible, an intolerable thirst is created, the blood becomes unfit to circulate and support life, and the patient dies in great misery. With the help of saline solution the worst case has a fighting chance, and the torturing distress of an intolerable and unrelievable thirst is avoided.

The obstruction of peritonitis is due to paresis and kinking. If the bowel is never over-distended there will be neither. The indication

is, therefore, to try to keep it empty from the beginning. Calomel and saline medicines, eserin, and especially pituitrin will often act well at an early stage, and one should begin soon with them. At a later stage after free use of saline instillation again they may be successful, especially with a stimulating enema containing turpentine. After meteorism is established, their action is always problematical, and failure frequent. When it is quite certain that the drugs all fail and meteorism is present, even although the patient is very ill, a small opening should be made below the umbilicus, and sufficient of the first distended piece of small bowel met with drawn out, lightly clamped, and one of my small glass intestinal tubes (Fig. 96) introduced, to which an india-rubber tube is attached for draining off the fæces. If success is attainable it will be prompt. The portion of bowel emptied regains its contractility. Coil after coil is emptied into it until in time all becomes unkinked and active again. The fistula in four or five days leaks on the surface, and care must be taken to protect the skin as far as possible. Usually, however, by the time the leak occurs the danger is passed, the tube may be removed, and one large, deep, mattress suture of silver wire will control the opening, and generally cause it to heal without further trouble.

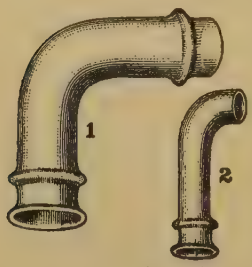

Fig. 96.—(*Paul.*)

Such in outline is the treatment of a most important and encouraging group of cases, important because among them are many of our most serious and interesting surgical emergencies; and encouraging because in a single generation they have changed from being the most hopeless to become quite hopeful cases.

The Treatment of the Acute Mechanical Obstructions.—These cases most imperatively call for early operation. If all could be taken in hand at once there would be little or no death-rate; whereas under an expectant medical treatment in past years very few of the genuine cases recovered. Diagnosis was not then so reliable as it is now, since "anti-mortem" pathology was practically an unknown science, and functional and organic troubles were liable to be confounded. Modern experience assures us that if a strangulation is released, an intussusception reduced, or a volvulus untwisted before the tissues have been hopelessly damaged, the patient will have an uneventful recovery. It is only when an improper delay has been allowed that danger is encountered.

Still we must admit the difficulties that surround both the practitioner and the patient, and recognize that under present circumstances it is impossible to get all cases in this desirable early stage. The surgeon must preach early operation, but be prepared to act at any stage of the condition presented to him. It can very rarely be his duty to accept the responsibility of postponing an operation when there is reason to believe the patient is suffering from a mechanical obstruction. Possibly in his anxiety not to lose valuable time he may occasionally operate on a mistaken diagnosis, but, as Howard A. Kelly writes, "that sin of commission is venial and rarely committed, compared to the frequent mortal one of the conservative omission." (Gynecology and Abdominal Surgery, Kelly and Noble, 1908.)

The general plan of operating is to incise in the middle line below the umbilicus and at once to explore the cæcal region, no bowel being allowed to escape. If the cæcum is distended and it is not an intussusception, which is very rare except in young children, and if there has been no previous chronic stenosis, the case is probably one of sigmoid volvulus, which is also rare. As a matter of fact, the great majority of acute obstructions in the large bowel (excluding intussusception) are due to the sudden occlusion of a malignant stenosis; but the diagnosis may be made difficult owing to the patient having failed to recognize the preliminary symptoms. If the cæcum is empty the collapsed ileum is picked up and followed to the obstruction. The distended bowel should not be drawn out and followed down, since by so doing the dangers of the operation are greatly increased. When the site and nature of the trouble have been ascertained each case must be dealt with on its merits.

The simplest of all is an omental or peritoneal band which has not cut through or otherwise vitally damaged the bowel. Its division at once releases the strangulation as in a hernia. The pale, empty "hunger" bowel begins to fill immediately, and the abdomen may be closed with a confident feeling that all will be well. If on the other hand the bowel is cut by the band, or is gangrenous, the greatest care is necessary to prevent any extravasation of fæcal matter while the damaged coil is brought out, clamped, and expeditiously excised. In doing this no mechanical apparatus is necessary or desirable. Cleanly remove the whole of the damaged part with a wedge of mesentery, and preferably in small bowel make an end-to-end anastomosis with suture, whenever the difference in size between the two ends is not so great as to prohibit it. The suture material for the first row of sutures

should consist of an absorbable substance, since it penetrates all layers of the gut and must therefore become septic. The suture is continuous, of the button-hole variety, and each stitch is drawn tight, in order that it may be hemostatic. When the circle is completed the last stitch is well knotted to the first, and the ends cut off short. The outer continuous row is of Lembert depth, and safely buries the deep layer of through-and-thorough suture. It may be of Pagenstecher's celluloid thread, or silk; but I much prefer the finer sizes of Lister's sulphochromic gut, which is the best material for all kinds of abdominal suture work except the parietes.

Before anastomosing the bowel, its condition above the obstruction must be taken into consideration. If distention paresis and kinking are present the removal of the obstruction and restoration of the canal will prove unavailing, and the patient's condition will be unrelieved. In such circumstances the bowel must be emptied, and this of course is

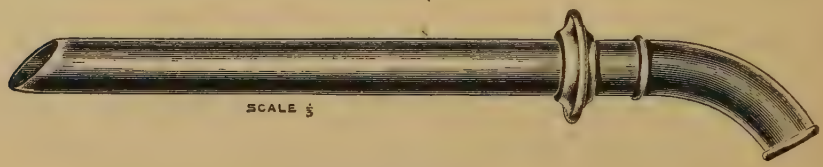

Fig. 97.—(*Paul.*)

best done before suturing the cut ends. Moynihan (Abdominal Operations) has called attention to the importance of this matter, and has suggested the use of a special tube (Fig. 97) on which the distended bowel can be carefully drawn and emptied. It is not necessary to empty all the small bowel, but enough must be evacuated to relax the abdominal tension, to release kinks, and enable peristalsis to be renewed. In the event of not being able to discover or deal with the obstruction without allowing the bowels to escape from the abdominal cavity, this must be permitted to happen, although there is abundant evidence that it seriously increases the danger of the operation. The escaped viscera should be wrapped in a warm abdominal towel (Baptiste lined with muslin), and it will generally be necessary or advisable to empty them before attempting reduction. If there are reasons for returning them intact Kelly's plan may be adopted. He inserts the edges of the towel in which the bowels are enveloped into the wound all round; then with the help of an assistant the edges of the wound are raised, and more and more of the towel tucked in until the bowels are reduced, and the sutures can be inserted. Only after this is done is the towel

extracted, and the sutures tied. But whenever such packing is necessary there is the greatest danger, indeed the greatest probability that paresis and kinking will keep up the obstruction.

Treatment of Intussusception.—The older methods of inflation and injection are now abandoned. They were very rarely effective and frequently harmful. Moreover they encouraged delay in operating, which is almost more fatal in cases of intussusception than in any other class.

So soon as a diagnosis of acute intussusception has been made the patient should be carefully anæsthetized in a warm room, and the abdomen opened through the right rectus. With as little disturbance as possible an attempt is made to reduce it by gently squeezing its distal end, thus gradually extruding the intussusceptum out of its sheath until all is reduced. This may be successfully accomplished during the first day or two, but after the third day the bowel is usually so altered and adherent that reduction is impossible. The course and the issue of the case now depend largely on the state of the bowel. If in good condition, which is unusual, a short-circuiting round the invagination may be accomplished with a fair prospect of success. If on the other hand, as is unfortunately more usual, the intussusception is already gangrenous there is but one course, and that is excision. In the older and stronger patients, and especially in the enteric variety, a primary approximation may be entertained; but as a rule it will be necessary to bring the ends of the bowel out and establish a temporary artificial anus. Indeed in almost all gangrenous cases this should be done, and it is I believe most safely accomplished by Mr. Arthur E. Edmunds' variation of my original method of performing colectomy (Fig. 98). The latter operation will be described on page 261. The variation is that the clamping of the spur is made part of the primary operation in order to save the inconvenience and difficulties of a fæcal discharge from the small bowel, which excoriates the skin, and is a source of much unpleasantness and discomfort to the patient. Mr. Edmunds has had the bowel

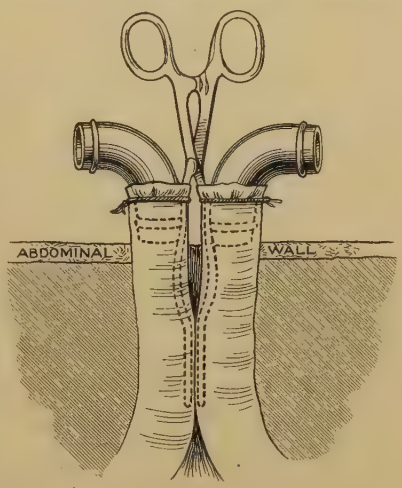

Fig. 98.—(*Paul.*)

tubes grooved to accommodate the blades of his clamp, so that tubes and clamp are applied and come away together. When the latter takes place the spur is already cut through, and the motion will at once begin to travel down the alimentary canal.

The mortality of the reduction treatment is very favorable; but up to the present that of resection has been disastrous. The future, however, holds out some hope of improvement, especially if the operation recommended is substituted for primary anastomosis.

When an intussusception involving the large bowel has been reduced, it is advisable to attach the cæcum and colon to the parietal peritoneum, both to prevent recurrence, and to retain the loose heavy mass of bowel in its normal position.

The massive chronic intussusception met with in adults is a rare and interesting surgical condition. It should I believe always be resected, whether reducible or not, both on account of the altered state of the bowel, and because a growth at the ileocæcal valve is a frequent cause for it. The results of resection are good.

The treatment of volvulus is on somewhat different lines to that of intussusception. In the first place it is a rare trouble, while the other is common; but what is of more importance is that the patients are older and stronger, and can consequently bear a serious operation better. This is well, for volvulus must generally be excised. The few cases in which it may be wise simply to reduce a volvulus are those which occur in the small bowel, and are not gangrenous, and especially such as are twisted round a pedicle of any sort. Some of these taken early are easily rectified, and recover quickly and completely. From what I have seen of sigmoid volvulus I advise excision in all cases, whether gangrenous or not. If gangrenous it is the only means of saving life. If not gangrenous the operation is not very dangerous, and is a necessary safeguard against recurrence. Theoretically it might be supposed that a volvulus of large bowel could be satisfactorily fixed, but this is not the case. It is too cumbrous and heavy to be properly dealt with in any way but resection.

The technique for the colectomy or enterectomy required for the removal of a volvulus is too similar in detail to that employed for other purposes to need a special description.

The Treatment of Obstruction Due to Cicatricial and Malignant Stenoses.—These strictures may be considered together, because when occlusion results the general condition of the alimentary canal is of more importance than the local, and the initial treatment will be

directed toward the relief of the obstruction rather than the cure of the stricture. The means at our disposal are (1) the establishment of an artificial anus; (2) short-circuiting; (3) excision.

The first is a simple operation; the second not at all serious if the patient is in good condition; the third is serious, and in bad cases dangerous. All relieve the symptoms which immediately threaten lifes therefore, one selects the operation in accordance with the patient's physical condition. It is a good rule not to resect bowel in the presence of complete obstruction unless absolutely necessary. In malignant stenosis there may be occasional exceptions to this rule—I think very occasional—but sometimes the general condition is still so good, and the stricture is so small and easily got at, that the majority of surgeons would at once undertake the major operation. However, I am sure this means not only more primary risk, but the future prospect is less hopeful than when the operation is undertaken with the advantages of empty bowels and an absence of all urgent symptoms. The alternative to primary resection is short-circuiting, or an initial colotomy. Colotomy has many advantages. It is the simplest proceeding, it gives the most effective relief, and it may be extraperitoneal and out of the way of a subsequent laparotomy. In old people and collapsed patients it is usually the only proceeding which offers any chance of tiding over the emergency. Of course it is applicable only to the large bowel, and practically to that part below the cæcum, as the drawbacks to opening the cæcum on to the surface are almost as great as those affecting the small bowel. When a colotomy is contemplated in these cases one has first to decide whether the peritoneal cavity is to be explored. In the presence of meteorism exploration is not easy, and is itself a cause of danger and increased collapse; therefore if from past or present symptoms it can be ascertained that the occlusion is below the cæcum, and if an internal strangulation such as a sigmoid volvulus can be excluded, it is better to do a right lumbar colotomy without a previous laparotomy. I prefer the lumbar operation for this purpose, and always place it on the right side, except when there is positive evidence that the stricture is in the pelvic colon or rectum. If certainly in the former, a left lumbar colotomy is better than a right, but since either is only intended to be a temporary measure the side is not a matter of great importance. When the stenosis is in the rectum, and the disease has advanced to the stage of occlusion, the time for excision has probably passed, and the left iliac operation should always

be selected as giving the best permanent result. Nor would this be contraindicated even if a subsequent resection could be contemplated.

The cases most suitable for short-circuiting are: (1) all non-malignant stenoses, (2) malignant stenoses of the small bowel or ileocæcal region unsuitable for resection; (3) any inoperable malignant stenosls of the large bowel which can be so relieved, and in which the patient is not in immediate danger from occlusion. The latter point is important in this way. When paresis has resulted from over-distention, short-circuiting does not drain the distended and kinked bowel any more than the simple removal of the source of obstruction does in the late stage in many of the acute mechanical cases. Colotomy has the same effect as emptying the bowel by Moynihan's tube, or by enterotomy in the paralytic obstruction of peritonitis. If the bowel empties itself persistalsis may be restored and recovery ensue, and it is because colotomy favors this end more than short-circuiting, that it is of infinitely more value in advanced obstruction of the large bowel.

Resection for stenosis should generally be reserved for malignant cases, always in the large bowel, and nearly always in the small. It is a serious operation, but with excellent prospects. If the operation is never undertaken during an attack of complete obstruction, and if it is carried out as will presently be advised the mortality is very low, and the expectation of life is very good.

The technique for the three operations is as follows:

Colotomy.—The lumbar operations are, with our present knowledge of abdominal surgery, quite simple, and may be carried out on the old lines, except that the incision should be smaller on account of the necessarily septic character of the wound. When employed for the purpose of relieving obstruction the bowel is always distended and cannot be missed. In cases of colitis the ascending colon may be empty and not so easy to find, but when this is so it is no more dangerous to open the peritoneal cavity in the loin than in the iliac region. Any prejudice against lumbar colotomy because it is accounted an old and superseded operation is unworthy, and should not be entertained. The colon should be opened where there are the greatest all-round advantages, and in exhausted subjects with occluded malignant stenosis these advantages are found in the lumbar operation.

Iliac colotomy is always selected when possible for a permanent artificial anus. There are many ways of accomplishing it, but the best is to open the bowel at once, and suture it to the surface. A short oblique incision (1½ in.) is made between the anterior superior spinous

process and the umbilicus. The sigmoid is picked up through this and passed between the fingers until the highest point, the short mesenteric iliac colon, is reached. This is drawn out and a small loop attached all round to the parietal peritoneum at the bottom of the wound by a continuous Lembert suture (Fig. 99). Only enough bowel is allowed to protrude from the surface of the wound to ensure that, when the convex border is cut off, the spur will be about ½ in. below the abdominal parietes. The next proceeding is to snip off this convex border, little by little, as a hemostatic suture attaches it to the skin (Fig. 100). The resulting orifice should be small, just sufficient to

Fig. 99.—(*Paul.*)

Fig. 100.—(*Paul.*)

comfortably admit a finger. If the spur is brought up to the surface a double-barreled opening results, which is large and patulous, and lacks control. The deeper spur, if not quite efficient at first becomes so in time with the non-use of the rectal part of the bowel. With this colotomy a mushroom-shaped plug is worn (Fig. 101) retained in position by a belt quite separate from it. The plug serves either to support a lax bowel, or to keep patent a tight opening. With it a patient of average health should have reasonable comfort, and not be debarred from following any ordinary avocation.

Cæcostomy when absolutely necessary may be done. A small piece of the distended cæcum is withdrawn, lightly clamped, and a small glass tube introduced in the usual way. The fæcal fistula resulting

will be unpleasant, and very likely the skin will be corroded by the liquid fæces. It should be replaced by some better permanent arrangment as soon as the patient's condition permits.

Short-circuiting is a very useful operation. It is performed on exactly the same lines as a gastroenterostomy. With a pair of curved clamps the two portions of bowel to be united are held side by side. The posterior half of the external Lembert suture is first inserted. Then the bowel is incised, and the complete internal ring of through-and-through hemostatic suture passed; the clamp is relaxed to see that there is no bleeding, and finally the external suture completed. There is no mortality from this operation *per se*, but in the presence of paresis it may fail to be effective. I make it a rule to short-circuit as closely

FIG. 101.—(*Paul.*)

as one reasonably may do round an obstruction. Thus if the occlusion is in the splenic flexure a much better practical result is obtained by short-circuiting the transverse to the descending colon, than by attaching the ileum to the pelvic colon. It is always best to put out of circuit as little bowel as will suffice to overcome the difficulty.

Resection of bowel for malignant stenosis is an operation much influenced by two things: (1) whether the stricture is in the small or large bowel; (2) the probable degree of malignancy of the tumor. In small bowel the fæces are liquid, and easily pass a portion of bowel temporarily narrowed by operation. In large bowel, particularly at a time when everything tends to encourage stasis, the fæces are certain to be semi-solid or solid. In this way a mass collects just above the wound in the gut, where it behaves rather like a foreign body, and is liable to imperil the safety of the union. Therefore a primary anastomosis

is much better suited to small than to large bowel. The fæcal discharge from small bowel is moreover so corrosive that it may endanger surface union; while that from the colon, though unpleasant, is not very harmful. In fact all details point to primary anastomosis being most suitable for small bowel enterectomies, but that colectomy should be accomplished in two stages.

The second point is the malignancy of the growth. This has been discussed at page 233. In small bowel all growths are best regarded as belonging to a rather decidedly malignant type, and it is advisable to give them a fairly wide margin, taking care to secure all the adjacent mesentery with its glands. In the large bowel the soft fungating tumors may be excised just well clear of the growth, and the glands though enlarged need not be widely removed, since they are only occasionally malignant, and are then usually easily recognizable as such. In ring strictures as much bowel as can conveniently be spared should be taken, since these strictures are more malignant and infective than they seem. In colloid growths it is better to short-circuit than to excise unless the circumstances are favorable, as they are very malignant both locally and secondarily.

The operation employed for the removal of a malignant stenosis of the small bowel is practically the same as that used for a traumatism, and does not need special description; but in the colon I almost invariably use an operation which I first performed in 1892, and published in 1895 (Liverpool Medico-Chirurgical Journal). The tumor is located, and a sufficiently free incision made over it to expose it and define its limitations. The mesentery is then divided longitudinally far enough to permit the loop of bowel containing the tumor to hang out of th abdomen. In doing this the vessels are first ligatured on the parietal side and clamped with compression forceps on the bowel side of the mesentery, so that there shall be no bleeding when it is cut. Next the longitudinal wound is closed vertically, and the two limbs of bowel are lightly sutured together so that they lie side by side like the barrels of a gun, thus forming a spur which may be safely clamped at a later stage. Now both limbs of the bowel are opened beyond where they have been sutured, but well clear of the growth, and a glass tube is firmly ligatured into each, when the coil of gut containing the growth can be cut away without hemorrhage (Fig. 102.) The ends of the bowel round the tubes are cleansed, and the silk ligatures used for tying are passed through the skin to fix the parts. The parietal wound is sufficiently closed with fishing gut, and freely powdered with xeroform.

The tube in the distal end is plugged with gauze, while that in the proximal end is connected with a receptacle for fæces by a wide, soft, and thin rubber tube. In this operation there is practically no hemorrhage, and very little shock. In easy cases it seems little more serious than a colotomy. The tubes generally separate in from five to seven or ten days, and then motion discharges on the surface as in colotomy. In three weeks all sloughs will have come away, and a clamp of Dupuytren

Fig. 102.—(*Paul.*)

type (Fig. 103) may be applied. This clamp is allowed to remain on for about 48 hours, and is required to cut the spur down for some 3½ or 4 in. It takes about 10 days for the inflammatory hardness and swelling caused by the clamp to subside, and it is as well to wait for this before pairing the edges and bringing them together. I have now had a large experience of this operation and am satisfied that it is safe, efficient,

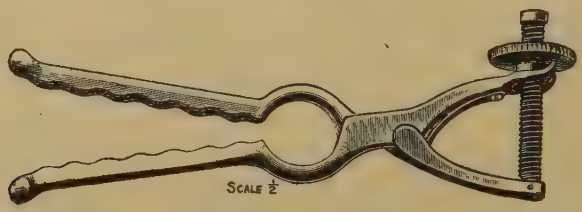

Fig. 103.

and permanent. It has the misfortune to postpone the period of recovery a few weeks beyond that needed when the ends of the bowel have been successfully approximated by suture, but I prefer a slow and sure method to one involving greater risks. When the disease is in the cæcum Mr. Edmunds' primary clamping is advantageous, as the proximal end is ileum, and discharges liquid, corrosive fæces.

Impactions.—Fæcal impactions rarely call for operative interference, though in exceptional cases it may be necessary to do colotomy or even colectomy. For foreign bodies, concretions, and gall-stones causing occlusion an enterotomy or enterectomy is necessary. The operation when no perforation has taken place is usually very successful. The body is easily found by tracing up the empty bowel from the ileocæcal region, and when found is removed by a sufficiently long incision on the convex border, which is closed in the usual way with a double row of fine suture. If the foreign body has damaged the bowel wall by pressure, or if it has led to a secondary volvulus, it may be necessary to modify the operation accordingly; but with smooth bodies as a rule there are no difficulties. In sharp angular substances on the contrary perforation is not uncommon, when a bad type of septic peritonitis is to be expected.

The most important points in the operative treatment of intestinal obstruction may be shortly summed up as follows.

LET THERE BE NO DELAY IN OPERATING

When there is collapse give saline injections before operating, and if necessary wash out the stomach.

In acute septic peritonitis remove the cause of contamination. Cleanse and drain the peritoneal cavity. Adopt the Fowler position. Stimulate the bowels to act at once, and use saline instillation. If obstruction continues, and especially if the vomit becomes fæculent, wash out the stomach, and drain the distended and kinked intestine with a small glass tube.

In acute mechanical obstructions incise in the middle line below the umbilicus, and follow the collapsed bowel up to the obstruction. If there is much distention and kinking always empty the bowels. When small bowel is excised an immediate end-to-end approximation is the best.

Acute non-gangrenous intussusceptions should be reduced. Gangrenous intussusceptions must be resected and the ends of the bowel brought out of the abdomen. Chronic intussusception in the adult is also best resected with a temporary artificial anus.

Recent volvulus of small bowel if not gangrenous may be reduced. Gangrenous volvulus, and all twists of large bowel, acute or chronic, should be resected.

Cicatricial and malignant stenoses of small bowel when favorable

should be treated by excision and end-to-end anastomosis; otherwise by short-circuiting.

In the large bowel when occlusion is present and strangulation excluded, a preliminary colotomy, especially right lumbar, is of great value. In the absence of occlusion cicatricial stenoses and inoperable malignant cases should be short-circuited if possible. When this cannot be done a permanent colotomy must be resorted to. In operable malignant cases it is safer to bring out the ends of the bowel and establish a temporary artificial anus, than it is to attempt primary approximation.

In impactions where there is no perforation or other dangerous complication, enterotomy is a very successful operation.

SECTION VII

PERITONEUM AND OMENTUM

By

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Anatomy and Physiology.—The peritoneum is a serous membrane lining the abdominal wall, save at such points as it is reflected on the contained viscera. It closely covers the viscera or parts of viscera with which it comes into contact.

Histologically it consists of (1) a single layer of flattened epithelial cells (so-called endothelium) and (2) a thin subserous areolar tissue which binds the serous layer loosely to the structures over which it is reflected.

The layer lining the abdominal wall is known as the parietal peritoneum, that covering the viscera or serving to connect the viscera to the body wall or to other viscera, as the visceral peritoneum. During life the walls of the serous sac are everywhere in contact and there exists no "peritoneal cavity" except for small capillary spaces between the viscera which contain a very small amount of thin greenish lubricating fluid—the liquor peritonei. In the male, the peritoneum is a closed sac. In the female, however, there exists an opening on either side at the fimbriated extremity of the Fallopian tube where serous membrane meets mucous membrane and thus a passageway to the outer air is afforded.

The peritoneum is divided into two main subdivisions; the greater and lesser sacs. These communicate with each other through an opening, the foramen of Winslow, situated beneath the caudate lobe of the liver. The lesser sac is situated behind the stomach and extends from the foramen of Winslow on the right to the hilus of the spleen on the left and from the diaphragm above to the transverse mesocolon below. The remainder of the peritoneum constitutes the greater sac.

According to their function, various portions of the peritoneum have received different names:

An omentum is a fold of peritoneum connecting the stomach with another viscus.

A mesentery, in its broader sense, is a fold of peritoneum connecting a portion of the intestinal canal to the abdominal wall.

A ligament is a fold of peritoneum connecting one of the solid viscera either to the abdominal wall or to another viscus.

The great omentum is a reduplicated fold of peritoneum which, attached above to the stomach and transverse colon, passes downward in front of the intestines and terminates in a free edge. It contains between its folds masses of fat and occasionally small serous cavities, omental bursæ.

The function of the peritoneum is three-fold.

1. To afford mechanical support to the viscera contained within the abdominal cavity.

2. To afford smooth opposed surfaces in order that the contained abdominal viscera may glide over one another without friction. This is accomplished by (*a*) the structure of the membrane, and (*b*) its power of secretion.

3. To absorb and carry away, by its free communication with the lymphatics, deleterious products which may enter its sac.

Effusions into the Peritoneal Cavity.—By these are chiefly meant non-inflammatory effusions of blood serum into the normal peritoneal cavity (ascites) but it is quite common in tuberculosis or cancer to find ascites and chronic peritonitis side by side, and ultimately we may find that other causes of ascites may also produce low grades of inflammation. Pure ascites is entirely due to general mechanical stasis of the circulation such as results from renal and cardiac disease and from local obstruction in the portal vein and in hepatic cirrhosis. Mixed ascites in which the two elements, mechanical and inflammatory, may cœxist, are seen in tuberculosis and cancer. Some of the largest and most rapid accumulations occur in the latter disease, and these may be as rapid, as in portal obstruction. Small effusions are difficult of recognition.

Collections of fluid in ascites should not contain over 3 per cent. of albumin; the natural hue is yellow. A cloudiness or bloody tinge suggests tubercle or cancer.

In a persistent ascites, puncture may become necessary for the patient's relief. In rare cases this procedure (or even medical treatment) is curative. The operative cure by Talma's method (suture of the omentum to the abdominal wall or to the liver in cirrhosis) has had but a limited success. At present, promising efforts are being made

with auto-drainage, allowing the ascitic fluid to escape beneath the skin.

DISEASES, INFECTIONS AND INJURIES OF THE PERITONEUM

Idiopathic affections of the structure are so rare as to be almost negligible. The membrane, which nearly equals in extent the superficies of the body, covers a great number and variety of viscera, and when it is infected from one of these it constitutes a secondary complication, which, however, greatly overshadows the original lesion, as must necessarily be the case with so extensive a structure. Certain peculiarities of the peritoneum in disease are as follows: 1. great tendency to absorb organic material even when in solid shape—if the material is toxic the system may readily be poisoned; 2. secretion of a fluid closely resembling blood serum, which has bactericidal properties; 3. upon local irritation of any kind a plastic exudate appears which produces adhesions and encapsulates solid foreign bodies.

Acute Circumscribed Peritonitis.—This may be aseptic or infectious. The first named, due to non-bacterial causes (escape of sterile cyst contents, bile, etc.), has a natural tendency to self-limitation and healing by adhesions. Low forms of aseptic inflammation accompany certain mechanical conditions interfering greatly with the circulation, as in volvulus, torsion of pedicles of tumors, etc.

In the infectious type of circumscribed acute peritonitis the conditions resemble those at first seen in the acute, diffuse form. The exudate may be highly infectious and yet may become walled off by adhesions. This wall may rupture from the *vis a tergo*, and the peritoneum at large become suddenly infected. As a rule, however, a mass of exudate appears which tends to encapsulation. Should this become an abscess the exudate increases in size, with, as a rule, general reaction. Any exudate, even a purulent one, may remain encapsulated, or an abscess may point and discharge, the peritoneal cavity usually escaping. These encapsulated exudations and abscesses are seen especially about the appendix and female adnexa. The surgical management will be governed by the symptoms in the given case.

In diffuse or progressive peritonitis (sometimes erroneously called general) there is practically a purulent inflammation, preceded by a fibrinous exudate. The causes of suppuration are generally pyogenic

germs which have penetrated through the intestinal wall, and the pus is generally dark and fetid. The fulminating type, which kills in a few hours without producing any macroscopic inflammatory change in the peritoneum, is doubtless toxic. The subject is overwhelmed with the dose of toxic matter given off by the bacteria.

The variety of germs known to cause purulent peritonitis is in accord with the manifold sources. In some cases the germs proceed from the blood itself, causing the so-called idiopathic peritonitis. Gonococci come from the sexual organs, colon bacilli from the intestine, the ordinary pyogenic cocci from the rupture of abscesses. The source, in the order of frequency, is the appendix and other portions of the gastroenteric canal, the female genitals, the gall-bladder, the urinary bladder, etc.

When the perforation of abscesses and of hollow organs is very sudden the patient develops so-called shock. There may be the sudden absorption of toxic material, and quick death.

The classic description of general peritonitis[1] is well known; the "pinched" facies, the rigid abdomen, the clear sensorium (often euphoric), the thirst, constipation, vomiting, pain, meteorism, hiccough, etc. The pulse is always a most valuable sign. A sthenic pulse accompanies the primary reaction of the system, and a toxic or asthenic pulse marks the close. The temperature is generally low rather than high, and this is a bad sign when accompanied by a fast pulse. A low temperature and normal pulse may have no absolute prognostic value.

The phenomena of peritonism or simple irritation precede in order and degree the symptoms of peritonitis. In the first-named the abdomen is board-like and often slightly retracted; the peritoneum is the seat of intense pain, and the abdomen assumes a fixed position for the protection of the inflamed intestines. The intestines undergo paresis with abolition of peristalsis and the paralyzed intestine quickly inflates, causing meteorism and a condition equivalent to paralytic ileus. Under such conditions any fæces passed are apt to come from the colon. The meteorism may become extreme, giving to the abdomen a barrel shape. The abdominal muscles retain their tension.

It is not always easy at the onset to discriminate between acute local and acute diffuse peritonitis. Diffuse peritonitis chiefly resembles obstructive ileus.

The surgical treatment of acute, diffuse peritonitis lies in the

[1] The reader is referred to the article on Appendicitis by Dr. A. J. Oschsner.

early opening of the abdomen, suitable evacuation of the fluid, and, if possible, extirpation of any accessible focus or its "walling off" with tampons. The entire cavity should, if possible, be cleansed quickly, and should be drained in a suitable way (suprapubic drainage), the Fowler position, salt solution guttatim (Murphy) by the rectum. If vomiting should persist, stomach lavage will prove most valuable.

Chronic peritonitis may be primarily divided into exudative, adhesive and tuberculous. The first may be briefly described as representing at times a protracted involution of an acute peritonitis and at other times a tuberculous peritonitis. Some cases seem to develop spontaneously. The affection appears as an effusion with thickened peritoneal walls. If these cases prove obstinate or severe, tuberculosis may well be suspected.

More important is the *chronic adhesive peritonitis*, which almost always comes on insidiously. Through the adhesions set up between the viscera the consequences may be many and far reaching. This condition may occur after certain injuries including operative ones, but occurs especially when organs beneath the membrane are inflamed; these adhesions are most common about the appendix, gall-bladder, adnexa, pylorus (ulcer). In certain cases there is no evidence of inflammation of other organs. The peritoneum becomes inflamed over the omentum or mesentery and leads to cicatrization and deformity. These adhesions may do great damage; various organs with a musculature lose their power of contractility. Stenoses are common. In addition to simple adhesions, bands may form which lead to kinking or strangulation. Some of these are clearly not of inflammatory origin. They may be present in the fetus, and may seem to develop on a phylogenetic basis to offset the tendency of the viscera to ptosis (Lane). (For a full account of these formations see articles by Lane, Jackson, Jonnesco and others). They appear to produce the same disorders as purely inflammatory adhesions. Such adhesions, of whatever nature, are treated by division with or without the addition of suitable anastomoses.

Chronic Infections.—*Tuberculous Peritonitis.*—An essentially localized tuberculous infection of the peritoneum causing a low form of peritonitis, generally pursuing a slow course and limited very largely to children and adolescents.

Causation.—While the affection is due to the ordinary form of tubercle bacillus, it is often difficult to state by which route it reaches

the peritoneum. Many cases are secondary to tuberculosis of adjacent organs.

Pathology and Symptoms.—As a rule small and scattered nodules coalesce to form large masses of tubercle which tend to undergo fibrous or fibrocaseous transformation. Exudates varying with the character of the lesions form and may become encysted. Simple fibrinous exudates form ordinary adhesions. The symptoms are often latent for months, but as a rule health steadily fails. Eventually a peritoneal reaction sets in, with board-like retraction or meteorism or marked ascites, and with vomiting, pain, constipation, etc. If the given case goes on to a fatal termination death occurs with the cachexia of a characteristic type.

The diagnosis is often most difficult in the early stages and may be determined only by an exploratory laparotomy. This diagnostic laparotomy at times proves curative although it is not definitely known how and why this should be the case. A focus of infection should be sought and when possible removed. Not infrequently will this focus be found in the pelvic adnexa or in the neighborhood of the cæcum. The patient should always be placed under the best possible climatic and hygienic conditions.

Injuries of the Peritoneum.—The membrane is very tolerant to sterile injuries, but a penetrating object may be soiled, or germs may enter the open port. Should an abdominal viscus be injured at the same time, suppuration or rapid general peritonitis may result. Small punctured wounds or those which close by valve-like action may escape infection. The danger of internal hemorrhage is quite separate from that of infection.

Unless there be definite contraindication, any true or suspected injury to the peritoneum should be thoroughly explored. The surgical procedure should be carried out at the earliest possible moment. (Exceptions to this may obtain in military surgery.) Should lesions be discovered they should be thoroughly dealt with on general surgical principles. The percentage of recoveries in stab wounds or gunshot wounds of the abdomen or in contusions of the abdomen with injured viscera is definitely proportionate to the promptness with which the condition is discovered and dealt with.

Neoplasms.—These may be roughly divided into malignant and benign growths. Malignant growths are generally secondary. Secondary carcinosis and sarcomatosis of the peritoneum proper are fairly

common. Primary sarcoma of the omentum may at times be found and should be thoroughly removed.

Primary benign growths of the peritoneum proper, or of the omentum, are generally cystic and may be of the hydatid type. The diagnosis is not apt to be made without trial laparotomy, and the management consists in the most thorough possible extirpation.

Larger or smaller portions of the greater omentum often require removal in the course of operations for hernia, appendicitis and other conditions. Removal of such portion or portions of the omentum should always be made with the greatest care and with the thought of the possible occurrence of secondary hemorrhage. Locked, chain ligatures, preferably of an absorbable material, should be used, and "buttons" of adequate size should be left beyond the ligatures in order to forestall the possible slipping of the ligatures themselves.

(In the preparation of the foregoing article use has been made of the work of Poppert in the textbook on surgery edited in 1909 by Wullstein and Wilms, as well as of the work of Pissavy.)

SECTION VIII

RECTUM AND ANUS

By

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ANATOMY

The Rectum.—The rectum or terminal portion of the intestinal tract extends from the levator ani muscle to the third sacral vertebra. The rectum has no mesentery but a small portion of its anterior surface is covered by peritoneum, especially in the female. It is developed from the cloaca or hind gut and terminates in the anal canal. The anal canal is derived from the ectoderm and extends from the margin of the skin through the inner sphincter where the rectum proper begins.[1] The rectum or ampulla is from 4 to 5 in. in length, is lined by thick vascular mucous membrane of the columnar epithelial type. The mucous membrane lies in thick irregular horizontal folds, most of which entirely disappear when the organ is distended. At from one to four points in the ampulla the folds become more prominent, when the bowel is distended, and extend into its cavity in a crescentic form. Ordinarily there are three of these folds, the superior, the middle, and the inferior. They are known as the valves of Houston. (Fig. 104.) The middle fold is the more constant and always lies just below the cul-de-sac of the peritoneum. There is a well marked valve of mucous membrane at the juncture of the sigmoid and the rectum. This valve is composed of two thicknesses of mucous membrane with some submucous and muscular tissue at its base and is attached to the wall of the intestine throughout one-third or one-half of its circumference. This attachment, however, is not on a horizontal plane, one end being slightly higher than the other. Its function is to support and let down gradually the fæcal mass in its descent through the rectal canal.

[1] Note.—Many authors, especially American, divide the rectum into three portions: the first portion, beginning at the left sacro-iliac synchrondrosis, extends toward the midline for about 3 in. and has a complete mesentery. Treves and Jonnesco have shown this to be the terminal portion of the sigmoid. The second portion, which curves back and occupies the hollow of the sacrum, has no mesentery and is derived from the cloaca, a highly differentiated part of the hind gut. This is the true rectum and it extends to the internal sphincter where the third portion or anal canal begins. This third portion or anal canal is from 1¼ to 2 in. in length.

The *submucosa* is composed of loose connective tissue through which pass the blood-vessels, the lymphatics and the nerves.

The *muscular coat* is composed of an outer longitudinal and an inner circular layer. These layers are continuations of the same layers of the colon.

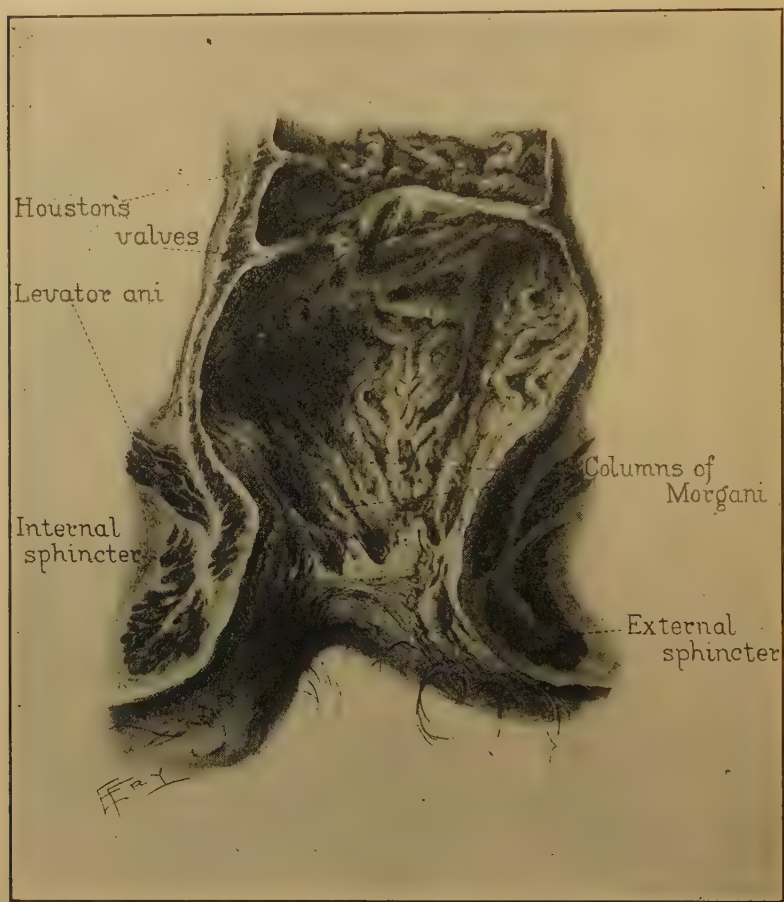

FIG. 104.—A longitudinal saction of a rectum showing ampulla and anal canal.

The *nerve* supply of all the muscles except the external sphincter is from the sympathetic.

The *blood supply* is from four sources: (1) the superior hemorrhoidal, a single direct branch of the inferior mesenteric artery reaching the intestine at the second sacral vertebra where it divides into two branches which descend on either side of the rectum, and each of which breaks

up into several branches which anastomose at the lower end of the bowel with the branches of the middle and inferior hemorrhoidal arteries, thus forming a rich vascular plexus; (2) the middle hemorrhoidal from the anterior trunk of the internal iliac or from the inferior vesical, which supplies the lower part of the bowel and is assisted by (3) the inferior hemorrhoidal branch of the internal pudic; (4) the middle sacral artery from the abdominal aorta which also sends branches to this part of the intestine. The rectal venous circulation starts from the hemorrhoidal plexus which is a venous circle about the rectum partly in the muscular and partly in the submucous coats. The blood passing into the superior hemorrhoidal veins goes through the inferior mesenteric vein into the portal circulation while the lower portions of the plexus empty into the middle and inferior hemorrhoidal and sacral veins, thence through the iliac into the general circulation through the vena cava. The vesical prostatic plexus communicates with the hemorrhoidal plexus. The hemorrhoidal veins have scanty support in the loose cellular tissue of the rectal walls and are prone to varicose conditions due to hydrostatic pressure of the portal column of blood and to pressure from the fæcal contents of the rectum and to stasis in the liver.

The Anal Canal.—The skin about the anus is pigmented and held in folds by the action of the external sphincter. The mucous membrane lining of the lower part of the canal is composed of cells similar to the epithelial cells of the skin while the mucous membrane of the upper part of the canal is of the columnar-cell type similar to the lining of the rectum proper. This mucous membrane lining of the anal portion is gathered into longitudinal columns or folds known as the Columns of Morgagni. (Fig. 104.) Between these folds are pits which often entrap foreign substances resulting in irritation and perforations. The more important structures of the anal canal are the sphincter muscles which completely encircle the internal and external parts. Ordinarily the external sphincter which controls the exit is in a constant state of chronic contraction. This muscle is composed of voluntary striped fibers, attached posteriorly to the coccyx and anteriorly to the central point of the perineum. It is supplied by branches from the sacral nerves coming chiefly through the pudic nerve and its branches. The internal sphincter is simply a thickening of the circular fibers of the middle coat of the bowel. It receives its sympathetic nerve fibers through the hypogastric plexus.

The *lymphatics* of the rectum proper pass to the sacral and lumbar glands, those from the anal region pass to the inguinal glands.

The *function* of the rectum is that of a receptacle for fæcal matter after it has passed through the alimentary canal. The physiologic function of the rectal mucous membrane is one of both excretion and secretion. It has a great capacity for the absorption of fluids.

Examinations.—The necessity for making thorough and careful examinations of the rectum cannot be too strongly emphasized. The patient's complete history should be taken and a digital and visual examination made in all cases in which patients complain of symptoms that refer to the rectum. A brisk laxative should be given the night before, and the evening and morning meal omitted. The lower bowel should then be thoroughly washed with one or more enemas a short time before the examination, which should be made with the patient in the knee-elbow or the left lateral position. The educated index-finger is the most valuable means we have for exploring the lower 4 or 5 in. of the rectum. A rubber glove or finger stall lubricated with vaseline or oil should be worn. A tender spasmodic sphincter may indicate some acute disease near the anus while a flaccid or lax sphincter is an indication of malignancy or of constitutional disease. In addition to the condition of the sphincters, special attention should be paid to the parts about the anus, the mucous membrane of the anal canal and of the rectum proper. Ulcerations, polypi, strictures, swelling in the rectum or bulging into it from the outside and the presence of fissures and fistulæ should be noted. The prostate and the seminal vesicles in front and the coccyx behind should be palpated. For a thorough inspection of the interior of the entire rectum either by means of a speculum or proctoscope there is no position so advantageous as the knee-elbow position with the thighs well flexed. In this position, the abdominal viscera fall away from the pelvis, and all fæcal contents gravitate from the field. Illumination of the interior is best accomplished by internal electric illumination. By the aid of the modern proctoscope in the hands of a skilled operator an examination of the mucous membrane of the anal canal, rectum and lower sigmoid can be made. Ulcers and fissures may be treated, polypi removed and specimens excised from suspicious growths for microscopic examination.

The pneumatic proctoscope designed by Tuttle has incorporated in it the two most useful parts of a proctoscope, *i.e.*, the internal light and the air window and bulb which makes it possible to balloon the bowel so that every square millimeter may be seen. The patient should be

instructed to strain slightly as the instrument is introduced into the sphincter. The instrument will thus pass through the area of the sphincter by one firm boring movement. The obturator can then be removed and the air-window put into place. In some cases it is not necessary to force in air since the bowel is completely relaxed, but, when the patient strains continuously, the bowel should be slowly ballooned out until the lumen appears in sight. The instrument should not be pushed into the rectum blindly. The operator should always see lumen ahead before pushing the instrument farther. A metal swab-carrier and specimen-taker should always be at hand with which to keep the instrument clear of fæcal matter and to remove specimens for examination. Braasch is now photographing lesions of the mucous membrane of the rectum, using a camera devised by Wilson which has been attached to the Tuttle proctoscope.

Deformities.—The study of embryology has aided greatly in understanding the nature and classification of congenital rectal deformities. The rectum proper is developed from the hypoblastic and mesoblastic elements of the posterior part of the hindgut. In the early embryo this is represented by a sac called the cloaca, which is the common ending of the alimentary canal and genito-urinary ducts. During the second month of intra-uterine life the cloaca becomes divided into two parts by a longitudinal septum called the perineal partition. In the anterior compartment thus formed the genito-urinary apparatus develops while the posterior part becomes the rectum proper. The anal canal also develops during the second month of intra-uterine life, its formation beginning by a depression in the epiblast which lies in line with the rectum and is called the proctodeum. The anal canal is at first separated from the rectum by a layer of epiblastic tissue, *i.e.*, the cloacal membrane which usually disappears about the third month. Congenital malformations are not common, one such occurring in about 8000 or 10,000 births. The type of deformity varies according to the layer affected. Malformation of the rectum proper arises from arrested or irregular development in the hypoblastic or mesoblastic layers while malformations of the anal canal are due to irregular development in the epiblast.

The most common variety of so-called *imperforate anus* is one covered by a thin membrane with the rectum and anal canal fully developed. In some instances the membrane only partially occludes the canal. At times there is narrowing of the anus without complete occlusion or there may be entire absence of the anal canal (Fig. 105).

The location of the anus in these cases may or may not be indicated by the anal dimple. One of the more common of these deformities is a persistence of the cloacal membrane between the rectum and anal canal. These abnormalities may not be noted for two or three days after birth when it is discovered that the usual discharge of meconium has not occurred and that the infant's abdomen is becoming distended. Irritability and restlessness, much straining and vomiting follow. The child does not survive many days under these conditions, though occasionally one may live for several weeks with a very marked abdominal distention.

In the *rectum proper* the most common deformity is that of the persistent cloacal membrane between the rectum and anal canal (Fig. 106).

FIG. 105.—Rectum normally developed, and canal absent, one of the more common types.

FIG. 106.—Anal canal normal. Persistant septum. Cloacal membrane between rectum and canal.

This membrane may be in the form of a thin bulging septum or it may be a thick fibrous partition. In this event, it is impossible to determine whether or not the rectum has developed down to the septum. The rectum may be normally developed or there may be lack of development to any degree and in some instances a pouch of the peritoneal cavity may extend between the closed lower end of the rectum and the upper end of the anal canal. For this reason one should not open blindly through this imperforate membrane. In some instances the rectum may be entirely absent, the colon terminating in a pouch, or it may exist as a fibrous band. At the same time, the anal canal may be absent or it may be fully developed (Fig. 107).

Communications with the *genito-urinary tract* are due to a lack in

the development of the perineal partition which should completely separate the cloaca into two parts—anterior, genito-urinary and posterior, rectal. If the septum does not form throughout, the rectum may communicate with the bladder, vagina, vulva or in the male with the prostatic urethra. The anal canal may be normal or entirely absent. The more common of these deformities (about 50 per cent.) occur in the female in the form of a communication between the vulva or vagina and the rectum (Fig. 108). If this is a good sized opening, the true condition may not be discovered for some years. If the fistula is small and the anal canal absent, as is usually the case, there may be gradually increasing intestinal obstruction with all its symptoms.

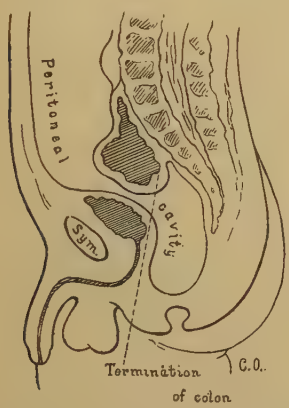

FIG. 107.—Absence of rectum. Anal canal normal. A pouch of the peritoneal cavity lies between colon and anal canal. Termination of colon.

FIG. 108.—Rectum emptying into vagina just inside the vulva. This is the common type of deformity.

Communication between the *rectum* and *bladder* or urethra is seldom seen. Occasionally a very small opening exists between the rectum and prostatic urethra (Fig. 109) which causes great annoyance from the passage of gas through the urethra. If communication between the rectum and bladder exists (Fig. 110) there are apt to be other evidences of malformation, such as complete absence of the anal canal, etc.

The treatment naturally varies according to the type of the deformity. If the condition is one of imperforate anus due to a covering of the outlet by a fibrous membrane this should be incised and the canal repeatedly dilated over a long period of time. If the finger can be passed into the anal canal but meets an obstruction at the rectum, a

speculum should be introduced and, if the obstruction proves to be a thin membrane bulging into the canal, it should be incised and the canal repeatedly dilated. In case of faulty development of the anal canal or rectum or when the rectum communicates with the bladder or urethra it is usually advisable to make at least a temporary left inguinal colostomy. If the child survives it is ordinarily best to postpone any further treatment until he is a least one or two years old, when a second abdominal operation may be made and if the rectum is fully developed an anal canal can be constructed and connected with the lower end of the rectum. If the anal canal is absent and the rectum opens into the vagina or vulva, it will not be necessary to do anything for some years unless the opening into the vulva is too small to allow the free escape of fæces. In this case, dilatation of the stricture under

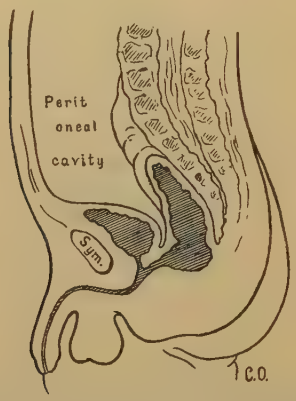

Fig. 109.—The rectum emptying into urethra. Anal canal absent.

Fig. 110.—Communication between rectum and bladder. Absence of anal canal.

an anæsthetic is sufficient for the time being. After some years, plastic procedures may be instituted to separate the rectum from the vagina, to close up the opening in the vagina and enlarge or reconstruct the anal canal. These artificial ani are usually without sphincteric control. Muscular innervation is not good and there is often prolapse of the mucous membrane.

Injuries of the Rectum and Anus.—The rectum and anus are most often injured by falls upon sticks, picket fences, rake and fork handles or an umbrella. The penetrating objects may either break through the skin and perirectal tissue into the rectum or they may enter through the anus, tearing the mucous membrane from the inside. The rectal

mucous membrane may be injured in the administration of an enema or by the use of a bougie. The rectum may also be injured by false passage of an urethral sound or in operation on the urethra and prostate through a perineal incision. In the cases of penetrating objects, the wound in the rectal mucous membrane may be very extensive and may be accompanied by extreme hemorrhage and shock. This is especially true if the bladder has been injured or the peritoneum penetrated.

Treatment.—If there is evidence of considerable injury a thorough examination of the upper rectum with the speculum should be made. If the injury has extended to the peritoneum, the abdominal cavity should be opened by a low incision for cleansing, draining, and repairing of wounded parts when possible. If the sphincter muscle has not been divided, it will often be well to cut through it in one place to prevent damming back into the rectum and to allow free drainage. Lacerations of the rectal wall and sphincter muscle during childbirth can usually be repaired so as to obtain a very satisfactory functional result.

Foreign Bodies in the Rectum.—Foreign bodies such as toothpicks, nails, fish-bones and pins may enter the rectum by passing through the entire alimentary canal. These usually are caught above the sphincter and may cause considerable laceration of the mucous membrane and often are removed with great difficulty.

Enteroliths, hard fæcal impactions and sometimes gall-stones become lodged in the rectum, causing severe tenesmus and pain. More often the foreign bodies are those which have been introduced into the rectum through the anus to hold back hemorrhoids or prolapses of the rectum or to make pressure under the prostate to facilitate emptying the bladder. Objects of all varieties have been introduced in this way by lunatics and criminals. Ulceration of the mucous membrane may result and the infection extend into the perirectal tissues producing an abscess in this region. These foreign bodies usually cause excruciating pain.

Treatment.—It is ordinarily best to anæsthetize the patient and paralyze the sphincter by stretching before attempting to remove the foreign substance. If the object is large or is firmly impacted into the wall of the rectum, the sphincter muscle should be cut in order that the mucous membrane will be traumatized as little as possible in its removal. The X-ray may be helpful in diagnosing foreign bodies high in the rectum.

INFECTIONS

Proctitis, or inflammation of the mucosa of the bowel, may be due (*a*) to the usual causes which produce inflammation of the digestive tract; (*b*) to gross errors in diet; (*c*) to sudden changes of temperature; (*d*) to heavy catharsis; (*e*) to too hot rectal injections or over-strong rectal medication. It may also be due to an extension of infection from above (colitis) or to direct infection from without as gonorrhœa and syphilis. New growths and foreign bodies are occasionally etiologic factors.

The onset in acute infection is sudden and characterized by chills and pain (especially at stool), localized discomfort, fever and a feeling of burning fullness in the rectum. There is frequent desire to stool and marked tenesmus. Usually the fæcal discharge contains blood and mucus. Absence of valves in hemorrhoidal veins and poor collateral circulation predisposes the rectal region to infections.

The diagnosis is made from the history and symptoms. The type of infection may be ascertained from the examination of the stool and of smears made from the mucosa. The proctoscope may be used to determine the extent of infection. In the specific infections (dysenteric, diphtheritic, gonorrhœal, tuberculous and syphilitic) are to be found the organisms which should always be looked for as a means of definite diagnosis. In both the chronic and acute types of infection, the symptoms are the same and ulceration usually follows. A chronic atrophic condition is found when the inflammation is long continued. It is characterized by marked constipation and dry stools covered with mucus and blood. A persistent discharge of pus occurs in all these cases.

The treatment should consist of hot and cold water applications, rectal douches, sitz-baths, and insufflation of powders. Belladonna and opium suppositories may be used and exciting causes should be removed.

Periproctitis or cellulitis of the perirectal tissues is an affection usually caused by extention of infection from the bowel, perforation of the wall of the bowel, ulceration and follicular abscesses. Infection may be secondary to genito-urinary inflammations, such as prostatitis, periurethral abscesses and extravasation of urine. Traumatic and operative wounds and severe contusions of the rectum are sometimes underlying causes. Earle and Tuttle classify inflammations about the anus and rectum as follows:

(1) Circumscribed.[1]
  (*A*) Superficial.
    (1) Tegumentary.
    (2) Subtegumentary.
    (3) Ischiorectal.
  (*B*) Deep abscesses.
    (1) Retrorectal.
    (2) Superior pelvirectal.
    (3) Interstitial or submucous.
(2) Diffuse.
  (*A*) Perirectal cellulitis.
    (1) Gangrenous cellulitis.

Diffuse perirectal cellulitis is usually due to traumatic puncture of the rectal wall or to puncture during operation. This inflammation is most acute and virulent and involves all the perirectal tissues. It may extend into the pelvis and sometimes into the peritoneum. These cases are often fatal. When abscesses form, the infection is either primary as from an abrasion of the skin or it may e e secondary to infections of the neighboring organs or carried to the part by the blood. These abscesses are more frequently found when the resistance of the perirectal tissue has been lowered through trauma or debilitating diseases. The symptoms are pain, redness, swelling, fever, and chills. When surgical interference is deferred the abscesses may involve all perirectal tissues from the levator ani to the pelvis.

The *treatment* consists of thorough drainage instituted immediately after the diagnosis is established.

Anal Fissure.—An anal fissure usually begins as a small scratch in the mucous membrane of the anal canal due to tearing of the mucous membrane by the passage of an unusually large or hard constipated movement. This tear usually lies on the posterior border of the anus and may extend from the margin of the skin to the internal sphincter; it is usually about ½ in. long and being constantly irritated, becomes indurated at its edges and develops into an ulcer which may extend into the muscle-fibers of the sphincter. Its location on the margin of the anus is marked by a swollen skin-tag which simulates an external hemorrhoid and is called the sentinel pile, a condition frequently associated with hemorrhoids or fistulæ. Anal fissure lesion is most often seen in women in adult life. In the early acute stage, the pain is most

[1] Circumscribed inflammation and abscesses will be considered under "Abscesses in the region of the anus and rectum."

severe and during each defecation there is prolonged spasmodic contraction of the muscles which causes great suffering. As the ulcer becomes chronic the pain is constant, dull and aching in character, often radiating to the extremities. A digital examination is almost unbearable, because of spasm and contraction of the sphincter muscles. A persistent fissure may remain unhealed for months and the constant suffering produced be the cause of neurasthenia and a marked emaciation.

Operative treatment is the simplest and most effective in these cases and should be instituted under a general anæsthesia. The sphincter muscles should be gradually and completely relaxed by forcible stretching. The sentinel pile should be excised and the granulating indurated surface of the ulcer either curetted away or, if there be much induration, the ulcer should be entirely excised. If the sphincter muscle is unusualy firm and spasmodic, it is sometimes best to cut at least part way through the muscle-fibers at the base of the ulcer. If hemorrhoids are present, they should be attended to at the same time. The bowels are kept at rest for a few days and, if there be much soreness, it is best relieved by frequent hot sitz-baths and the application of vaselin. The sphincter muscle will regain its tone within a few days.

Ulceration of the rectum may be simple (traumatic) or specific (dysenteric, tuberculous, syphilitic, gonorrhœal, carcinomatous, actinomycotic, or a rare condition known as schistosomia hemotabium). Ulcers are the result of long-standing infection either simple or specific, or of local causes (trauma), such as hardened fæces and foreign bodies. Ulcerations sometimes occur in constitutional diseases such as diabetes, chronic nephritis, etc.

Simple ulceration is rarely seen before adult life and occurs most frequently in the middle aged female. It may be the result of chronic constipation causing an abrasion of the mucosa. If the mucous membrane only is involved, recovery will be complete, but, when the deeper coats are involved, there may be a tendency to the formation of stricture.

The treatment consists of correcting errors in diet, relieving constipation, and the local treatment of the ulcer.

Dysenteric Ulceration.—In the specific infection the condition may be primarily ulcer-formation. Dysenteric ulcers may be divided into bacillary and amœbic, and are usually secondary to ulceration of the colon. In bacillary infection the onset is acute with symptoms of chills, fever, griping, tenesmus, burning in the rectum, diarrhœa, liquid and finally bloody stools. The patients lose strength and weight rapidly and may collapse early. Diagnosis is made from the acute onset

and the findings of the Shiga bacillus in the stools. In the amœbic type the onset is insidious but may be acute. There are usually no constitutional symptoms except loss of weight and occasional rise of temperature. Patients complain of diarrhœa and some blood in the stools, marked tenesmus and burning in the rectum. The diagnosis is made on finding amœbæ in the stools or in scrapings from the ulcers. Through the proctoscope the ulcers appear to be superficial with ragged edges. They may be round or hour glass in shape. The mucosa may be slightly or markedly inflamed. The top of the ulcer is frequently covered with a grayish cap which is easily removed and leaves a bleeding base which is not greatly depressed below the surface. Beginning as many small ulcers, these may coalesce and form one large deep ulcer.

Treatment.—We have used rectal injections of coal oil as a local treatment in a number of these cases with good results. Ipecac. and emetin by mouth in large doses should be used. Salvarsan as a rectal injection and given intravenously has produced very striking temporary results. Lavage and medication by means of appendicostomy and colostomy are used by many surgeons. Some observers have reported cures after several months. Relapses, however, are frequent and constitute one of the characteristics of the disease.

Tuberculous ulcers are in the majority of cases secondary to tuberculous infection elsewhere in the body. In a number of patients we have found these ulcers in conjunction with pulmonary tuberculosis. They have a punched-out appearance with distinctly ragged edges (and are most often found in the anal canal (crypts of Morgagni). They are usually round but may coalesce, forming different shaped ulcers which spread around the circumference of the bowel. Firm nodules are felt in the mucous membrane about the ulcer. The tuberculous infection may involve the perirectal tissue by direct contact or by means of the lymphatics, when abscesses and fistulæ are the result. The symptoms are those found in simple ulceration, the severity depending on the nearness of the ulcers to the sphincter. Pain and diarrhœa are less marked than in other forms of ulceration. The diagnosis is made from the appearance of the ulcers, the finding of the tubercle bacilli in the stools or in the scrapings from the ulcers, and from the history of tuberculosis elsewhere in the body.

Treatment.—When the ulceration is extensive the treatment should be hygienic together with the exhibition of the usual tonics and foods. When not extensive the ulcers should be curetted and dusted with

iodoform powder or cauterized with materials such as pure carbolic acid or silver nitrate. The electro-cautery and high-frequency current may be used when there are but few ulcers. All treatment by cautery, either chemical or electric, should be used with great care as strictures will result when the cauterization is done too frequently or when it is too deep. In patients who do not stand local treatment well, warm douches containing some mild antiseptic should be used. Application of ointments containing a small percentage of some local anæsthetic and the introduction of suppositories of belladonna and opium are sometimes necessary to control pain and tenesmus.

Syphilitic Ulceration.—The primary lesion of syphilis which may apear around the anus, is seen more often in women. The secondary and tertiary lesions occur more often than the primary and are found in the ampulla. Such lesions are greatly indurated, extensive, destructive, and early tend to form strictures. The secondary ulcers found in the rectum have a crater-like appearance with sharply defined edges, the surrounding tissue being markedly indurated. Tertiary lesions or gummata are the most frequent syphilitic lesions found in the rectum. Gummata usually form in the submucous tissue and spread to the mucous and muscular layers. They appear as round or elongated masses with broad indurated bases. The tumor proper, when not ulcerated, is tough, elastic, rather smooth and hard to cut. Ulceration and sloughing frequently take place due to interference with the blood supply. The relaxation of the sphincter and the dry papery condition of the muco-cutaneous tissue is a constant finding.

The *diagnosis* in the primary lesions is based on history, positive Wassermann and the finding of the spirochæta pallida. In the secondary and tertiary conditions, a history of infection, the Wassermann after a provocative salvarsan dose, the history of present trouble, and an examination of tissue should determine the diagnosis. It must always be remembered that carcinoma may form on an old syphilitic lesion and that repeated examinations of the tissue should be made before determining the diagnosis.

Treatment must be thorough and prolonged. We have used both salvarsan and mercury by inunction with good results.

A rare form of ulceration of the rectum is part of a general infection with *schistosoma hematobium.*

Actinomycosis is rarely found in the rectum. When ulceration occurs it is secondary to infection in the intestinal tract.

Carcinomatous ulcers of the rectum are frequent and resemble simple

ulcers. The diagnosis is made from the examination of tissue removed from the ulcer.

Gonorrhœal ulcers follow long-standing gonorrhœal infection of the rectum. The finding of the gonococcus determines the diagnosis.

Strictures.—*Perirectal inflammation* which is secondary to inflammation in the surrounding organs may become so marked that the lumen of the bowel is narrowed. Spasmodic stricture may occur, caused by the constant irritation of an ulcer or sore in the rectum by the hardened fæces.

Simple inflammation causes stricture only when the fibrous tissue of the bowel is involved. Too deep cauterization and the removal of large pieces of tissue for examination have often resulted in stricture. Trauma from within or without the rectum and the resulting infection are very frequently the cause of extensive stricture, *e.g.*, the pressure of the fœtal head in prolonged pregnancy, the retention of large fæcal masses in the rectum and the removal of large pieces of bowel wall during operations.

Tuberculosis is a more frequent cause of stricture than was previously believed. In several cases at autopsy Tuttle was able to demonstrate tuberculous ulcers at the bottom of the strictures.

Syphilitic stricture, which is the most common variety in our experience, begins as an ulcer of the mucosa. Earle and Tuttle believe that a deposit of soft tissue then takes place and is followed by a colon bacillus infection.[1] This process extends to the circular muscular layer and although the ulcer may heal, the process continues in the muscular layer around the gut when organization with connective tissue takes place and a dense hard stricture results. During the healing of the ulcer, the symptoms subside. When narrowing begins, symptoms of obstruction are noted. There is a frequent desire to urinate which is followed by tenesmus and pus and blood in the stool. A drawing, fullness, pain and early incontinence of stool, if the lesion is near the sphincter, are constant symptoms. The length and dilatability of the stricture should be noted, also its distance from the sphincter, and the character of the surrounding tissue. When the lesion is above the finger's reach, the proctoscope or sigmoidoscope should be used. Specimens of tissue and scrapings should be thoroughly examined for spirochetes and a microscopic section of the tissue should also be examined. Findings in the Wassermann and tuberculin tests, the history of an

[1] Many authors believe that the commonly called syphilitic stricture is gonorrhœal in origin.

old lues, or the presence of tuberculosis elsewhere in the body are factors that should always be considered when making a diagnosis.

Malignant Strictures.—Malignant strictures occur usually after the fortieth year, but may be found in young individuals. We have found them in patients as young as 23 years. In most cases the tumor forms a large part of the obstruction and in circular growths it may cause complete obstruction. The history in these cases is shorter than in those of tuberculosis or syphilis, and a nodular growth may be felt or seen. There is marked loss of weight and strength and examination of the tissues shows carcinoma. In carcinomatous stricture the obstruction is abrupt while in syphilis it is a funnel-shaped contraction.

The treatment of these cases should be carried on while the lesion is still an ulcer; strictures may thus be prevented. The proctoscope should be used in every rectal case in order to establish an early diagno-

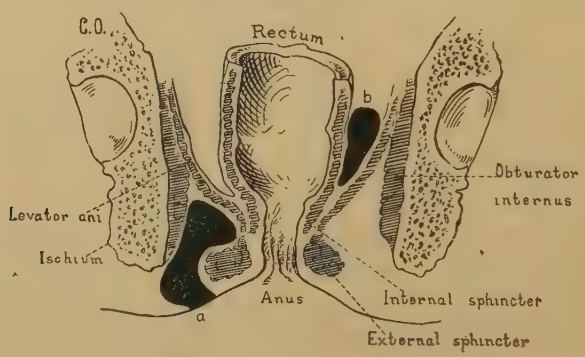

FIG. 111.—*a*, shows position of superficial abscess; *b*, shows position and location of deep abscess.

sis and begin treatment before gross changes take place. In the early cases before much scar tissue has formed and before the lesion becomes fixed, dilatation is a successful method of treatment. If the stricture has become organized, the bowels and diet should be regulated and the case treated surgically. In the early luetic cases, antiluetic treatment should be used to soften the contraction. Dilatation may then be carried on to arrest the progress of the disease. This procedure may be practised by the patient under the physician's direction by means of a soft rubber dilator. Metal or stiff instruments must be used with the greatest care in these cases because of the danger of puncturing the rectum. Rapid dilatation under ether is more often a post-operative procedure but with great care may also be used for the specific and tuberculous cases.

Abscesses.—(1) Circumscribed.

(*A*) Superficial[1] (Fig. 111).

1. Tegumentary.
2. Subtegumentary.
3. Ischiorectal.

(*B*) Deep (Fig. 111).

1. Perirectal.
2. Superior pelvirectal.
3. Interstitial or submucous.

The region around the rectum and anus is very susceptible to infection because of the large lymphatic and blood supply and the constant presence of organisms. In superficial abscesses the infection probably gains admission through abrasions of the skin, infections of hair follicles and small wounds. The infection in the skin may be slight in these cases, yet a large abscess may form. The infection probably passes through the lymphatics to a node where suppuration takes place and, as it travels so easily along the lymphatic channels, the abscess may form at some distance from the original infection. Many of the deep abscesses are caused by infection which comes from the bowel direct probably from minute punctures caused by foreign bodies in the fæces. Here, as in the superficial variety, the infection may be carried to the deep tissues by the lymphatics. These abscesses should be drained as soon as they are discovered.

Tegumentary abscesses originate, usually, in a sebaceous follicle or in relation to a thrombosed external pile.

The *subtegumentary* variety are usually the result of a follicular abscess. There may be several abscesses which coalesce and burrow a considerable distance under the skin. These abscesses rarely form fistulæ. The patient usually complains of throbbing pain, exaggerated by defecation. The sitting position is very difficult because of the marked tenderness. Rectal examination is painful. Locally, there is a small, very tender superficial tumor surrounded by an indurated area.

Ischiorectal abscess is a result of infection in the ischiorectal space (Fig. 112). These abscesses point toward the back of the rectum between the external and internal sphincters. They may burrow in all directions always following the line of least resistance and may occasionally invade the ischiorectal space on the opposite side. These abscesses are variously named according to their shape—horseshoe, dumbbell, etc.

[1] The superficial abscesses are formed below the levator ani muscle and the deep ones above the levator ani.

They find their exit through the skin either before or after opening into the rectum. The onset is acute, with chills and fever. At first the pain is dull but finally becomes very acute, and throbbing in character. Defecation is almost impossible because of the intensity of the pain. There is also difficulty in urination. The rectal examination shows very tense swelling in the ischiorectal space. When the abscess points early and evacuates itself, the acute symptoms are immediately relieved. Recurring acute symptoms are due to the sealing over of the fistula or to the burrowing of the abscess into the other ischiorectal space.

The deep *perirectal* abscesses are divided according to their anatomic situation. There are three spaces above the levator ani muscle.

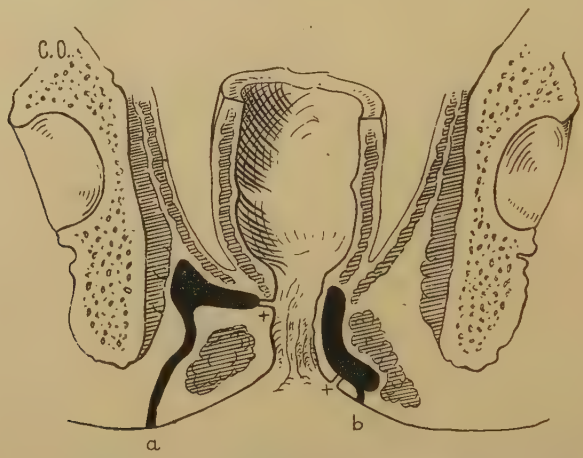

FIG. 112.—*a*, Ischiorectal abscess with sinus just outside of the anus; *b*, shows superficial abscess with sinus plus probable communication with the anal canal, often impossible to demonstrate.

Richet has divided these into lateral or pelvirectal, posterior or retrorectal spaces which occupy all the region between the rectum and the sacrum and coccyx. The blood and lymphatic supply of these spaces is distinct.

Pelvirectal abscesses are the more common of the deep abscesses found around the rectum. They are situated between the levator ani muscle and the rectum (Fig. 112). These abscesses are seldom due to injury and disease of the rectum. The majority originate in the pelvis, secondary to infection of the broad ligament and to infection or rupture of the bladder, prostate, or the uterus. Psoas and appendicular abscesses have been known to point in this region. Digital examination shows bulging into the rectum, usually found well above the internal sphincter.

The *submucous* abscess originates in the submucous tissue of the rectum and is usually due to injury to the mucous membrane by a foreign body. These abscesses tend to bore toward the anus and open close to the anal margin.

Treatment.—Free drainage is the only relief from the intense suffering caused by any of these types of abscesses. Nothing will be gained by the use of poultices or dressings after the location of the infection has been determined. Early opening of the abscess prevents burrowing. All the compartments should be broken into with the finger, a procedure which is especially applicable in the pelvirectal abscesses. During this time of acute infection and formation of abscess, the sphincter muscle should not be interfered with since, in severing the sphincter, incontinence frequently follows. Even if there is a distinct and com-

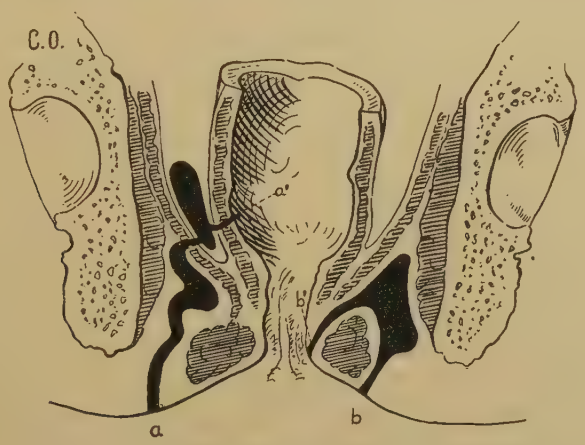

FIG. 113.—*a* and *a'* show complete rectal fistula; *b* and *b'* show anal fistula.

plete fistula, drainage of the abscess only should be instituted. After opening the abscess cavity it should be packed with soft iodoform gauze, which should be changed every two or three days. The after-care consists in frequent sitz-baths of about 30 minutes duration in water as hot as is bearable. This frequently gives great relief. Laxatives should be taken every few days. Injections of sweet oil, opium suppositories and vaselin may be helpful. If a fistula persists some weeks after the inflammation has subsided, an operation will be necessary.

Sinuses and Fistulæ.—Sinuses around the rectum and anus are the openings from an abscess cavity (Fig. 112). They heal in a short time. *Fistulæ* are the chronic outlets of an abscess cavity either within or external to the rectum or anus, and are the result of abscess forma-

tion or of some focus of infection. Fistulæ may be divided into the complete and incomplete varieties (Figs. 112 and 113). These may be either subcutaneous, submucocutaneous, or submucous. As fistulæ frequently open into adjoining organs they are also divided according to the name of the organ into which they empty or with which they communicate. Specific infections are sometimes the etiologic factor in their formation so that they may be subdivided according to the type of infection. The persistence of fistulæ is due in the majority of cases to constant reinfection from the rectum.

In *external incomplete fistulæ* there is usually an internal opening which is so small that it cannot be found with a probe before operation, but the constant reinfection of the tissue can be accounted for in no other way. At operation these openings are very frequently found.

Syphilitic fistulæ are usually of the anorectal variety and are the result of syphilitic stricture or ulcer.

Anorectal fistulæ is an abnormal opening between the anus or rectum and the surface of the skin. After acute symptoms of abscess have subsided the patient notices a chronic seropurulent discharge which at times may be thick pus, *i.e.*, when the patient strains at stool or after heavy lifting. The occasional discharge of pus is due to the rupture or spontaneous drainage of an undrained branch of the abscess or is due to a temporary sealing and sudden reopening of the fistula. The pain is slight but tenderness is marked and is increased at stool. A rectal examination should always be made in these cases. A hard, slightly indurated, area may be felt at the site of the abscess and the channels may be felt as indurated cords. A probe should be used while the finger is in the rectum in order that internal openings may be felt and the full extent of the abscess and fistulæ demonstrated. When openings are large they may be felt with the finger and without the aid of the probe. With the proctoscope (which should always be used when the patient's condition will permit) the mucosa around the internal opening is seen to be reddened and it may show granulation tissue. It is difficult to see the opening unless methyl blue has been injected or a probe has been previously passed. When the opening is very small and when it is in the folds of the sphincter it is sometimes impossible, except at operation, to demonstrate it. A radiogram made after the injection of bismuth or colloidal silver will show the ramifications of the fistulæ and their position with regard to the anus, rectum and sphincter. By this means we have often been able to find openings when other means failed.

In the *blind internal fistulæ* the opening is only into the bowel and is usually above the lowest point of the abscess. In this lesion the symptoms may be more acute and more severe than in the other varieties, because the high opening affords such poor drainage. The patient complains of fullness in the rectum with discharge of pus. With a finger in the rectum a tender mass may be palpated, which discharges pus into the rectum when squeezed. There are very frequently spasms of the sphincter.

Complex fistulæ have many branches and extend in all directions from the main tract. These are named according to their outline, as "horseshoe fistula," "waterpot fistula," etc. These complex fistulæ are the attempts of an abscess to find openings in many directions in the soft tissue around the rectum. According to Goodsall, fistulæ of the anterior quadrant open directly into the anus and rectum, the internal opening being perpendicularly above the external opening. Those in the posterior quadrant open near the posterior commissure and usually extend around the anus. Subtegumentary fistulæ open at any point on the anal circumference (and burrow in any direction under the skin as there are no interfering septa). Anterior fistulæ extend forward while the posterior burrow outward. Horseshoe fistulæ extend around the anterior or posterior commissure of the anus. Waterpot fistulæ are the result of poor drainage and the many branches burrow toward the skin and form external openings. Although they may have an equal number of internal openings, usually there is but one, which in most cases is situated in the folds between the two sphincters. Complex fistulæ are sometimes secondary to infection with abscess formation in the bones of the pelvis and vertebra. The abscesses burrow and form fistulous tracts which open into the anus or rectum or form external openings in the perineal tissue. These infections, in a large percentage of cases, are tuberculous. In spite of thorough drainage and treatment they continue to discharge pus; this, together with a history of involvement of the bone and a positive radiogram should determine the diagnosis.

Perineo-urethral fistulæ are the result of periurethral infection secondary to tuberculosis or gonorrhœa in the urethra. They are sometimes caused by rupture of the urethra. These abscesses burrow backward into the perineum and open to the anus. They are often thought to be anorectal fistulæ. A history of urethral infection and the passage of urine through the fistulæ are the diagnostic features.

Recto-urethral fistulæ are tracts which connect the rectum and the

urethra. The prostatic and membranous urethræ are most often affected. The rectal opening is above the inner sphincter in most cases. Traumatic rupture of these organs is the more frequent cause of the fistulæ. Prostatic abscesses and accidents during operations are common causes. In resections, the rectum may be opened and a fistula result. The presençe of fæces and gas in the urine, the passage of urine through the rectum, and the history of trauma or of operation make the diagnosis easy.

Recto-vesicular fistulæ are caused by puncture-wounds, more often during operations. They may be due to large inflammatory processes which extend from the bladder to the rectum. They may also be due to extensive involvement of these organs by carcinoma or syphilis. Direct opening may be found when the rectum and bladder are together; indirect fistulæ have abscesses intervening. Urine is always present in the rectum and gas and fæces are found in the urine. Clean puncture-wounds may heal at once. A permanent catheter in the bladder and the regulation of the stools are aids in treating these cases. It is also often advisable to divide the anal sphincter.

Recto-genital fistulæ are those connecting the rectum and one of the genital organs, *i.e.*, recto-vulvar, and recto-vaginal. The last-named fistula is the result of puncture during operation, or of prolonged pressure of the fœtal head during confinement. Syphilitic ulceration is also often the cause. Gas and fæcal matter are found in the vagina, causing a vaginitis and leucorrhœa.

Treatment.—Methods of treating rectal fistulæ and sinuses have been very unsatisfactory. In most of the cases several operations were required to obtain relief. Laying the whole length of the tract and all its branches freely open, curetting out the granulation and scar tissue and packing the wound to encourage healing from the bottom is one of the oldest and perhaps most common methods of treatment. But the wound is long in healing, and changing or replacing the pack is very painful. Incontinence frequently follows when the sphincter is cut in more than one place, and it sometimes follows when cut in only one place, especially if the incision in the muscle is oblique.

It has been said that operative treatment is satisfactory in less than 50 per cent. of these cases. One of the more recent procedures is to make a large free incision at the side of the rectum on which the fistula presents itself (Mackenzie). The dissection is continued straight along the rectum outside the sphincter muscles until the opening in the rectum is found. The infected tissue is then removed and the

opening into the rectum carefully sutured, the soft tissues being closed except for a small drain. This technique would seem to be especially indicated in case the internal opening is 2 in. or more from the anus. Another method (Elting) is to start as though a Whitehead operation were to be done, making the incision at the juncture of the skin and mucous membrane for the entire circumference. The mucous membrane of the rectum is then dissected free for some little distance above the internal opening of the sphincter, the distal part of the mucous membrane amputated above the internal opening and the edge of the mucous membrane sutured back to the skin to reëstablish the anus. It is essential, in dissecting out the mucous membrane, to include the mucous membrane and submucous only so as not to interfere with the muscular coat. This operation would seem to be especially indicated when the internal opening is not more than an inch and a half from the anus.

In a large percentage of the cases the internal opening is closer to the anus than is supposed. One disadvantage might be mentioned in regard to the Elting technique, that is, the possibility of stricture formation afterward. Many times, to avoid this possibility, I have extended the incision half way around the circumference of the anus, thus shifting down that half of the anal canal which contains the internal opening of the fistula, leaving the rest of the anal canal undisturbed.

A non-absorbable suture material (silk or linen) should be used in suturing the skin and mucous membrane together after that part of the mucous membrane containing the internal opening has been amputated. These interrupted sutures will come out of their own accord. We have had considerable experience with the operation, both as originally described by Elting and with this modification. It has proved satisfactory in a large percentage of the cases.

Hemorrhoids.—Hemorrhoids or *piles* are soft tumors which are situated about the anal orifice. They are due to a varicosed and hypertrophied condition of the hemorrhoidal veins. These tumors may lie either in the subcutaneous tissues of the anus external to the sphincter (external hemorrhoids) or in the submucous tissues of the lower part of the rectum (internal hemorrhoids). Hemorrhoids are seldom seen in children but are quite common in persons above 30. In many of these persons, however, the discomfort produced by their presence is of such a mild character that medical advice is not sought and relief is obtained by the use of the various pile cures on the market.

The most important of the many factors which contribute to the

production of hemorrhoids are probably conditions which cause repeated and prolonged straining efforts, such as partially ineffectual attempts to empty the rectum or bladder. Of these, chronic constipation, hypertrophy of the prostate, urethral stricture or vesical calculi are the most common. Hemorrhoids may also be produced by conditions causing obstruction to the return of the venous blood from the rectum, such as are seen in cirrhosis of the liver, heart disease, pressure from a pregnant uterus, or abdominal and pelvic tumors.

Two varieties of hemorrhoids are recognized: (1) external hemorrhoids, in which the dilatation is limited to the veins external to the sphincter, and (2) internal hemorrhoids in which the varicosed condition occurs in the veins situated within the sphincter. Frequently both varieties are seen in the same individual and the condition is then spoken of as mixed piles. In either variety thrombosis may occur, producing bluish oval indurated masses called thrombotic piles. Infection of these may occur giving rise to a localized phlebitis with occasional abscess formation and producing a condition known as inflamed piles.

Occasionally an hypertrophied tag of perineal skin is seen near the anus, which may be erroneously called an external hemorrhoid. These tags may measure ½ to 1 in. in length but contain no varicosed veins. Such tags are frequently seen at the lower end of a fissure and have been called sentinel piles. Internal hemorrhoids are the more common and the more important variety. These occur as spongy tumors in the mucous and submucous connective tissue covering the internal sphincter. Each pile consists of a central artery of variable size surrounded by numerous tortuous, dilated and hypertrophied veins and a varying amount of condensed connective tissue.

External hemorrhoids frequently cause no symptoms. They may, however, produce a feeling of fullness and itching about the anus when they become turgid during straining efforts. At times an external hemorrhoid either ruptures or has a clot form within the vein producing what is known as a thrombotic pile. Such a condition is accompanied by the rapid formation of a painful and tender mass. External hemorrhoids are frequently spontaneously cured by thrombosis and obliteration of the vessels.

Internal Hemorrhoids.—Individuals may undoubtedly have a certain amount of chronic dilatation of the hemorrhoidal veins without symptoms. In others the condition may exist for years with symptoms so mild in character that they require little attention. In such instances the symptoms will probably be a sense of weight or pain

in the rectum which is noticed only during or immediately after defecation. When, however, these tumors attain such a size that they are protruded from the anus during straining efforts, the symptoms become more pronounced. The hemorrhoids are then caught by the sphincter muscle and the return flow of venous blood interfered with, thus causing them to become turgid and painful. After the straining efforts have ceased the hemorrhoid may reduce itself, or it may be necessary for the patient to reduce it with a finger.

Hemorrhage.—Ulceration of the mucosa covering the hemorrhoids, may cause hemorrhage at each defecation. At times this may be quite profuse, producing in some instances profound anæmia.

Hemorrhoids of long standing are often accompanied by a considerable degree of prolapse of the bowel. It frequently happens that a person suffering with internal hemorrhoids will have these protrude, be caught by the sphincter and become strangulated. They will then rapidly swell and it may be difficult or impossible to replace them within the sphincter. In such instances the pain is severe and is accompanied with local tenderness and possibly fever. Such patients are unable to walk and are confined to bed.

The *diagnosis* usually presents no difficulties and can be made by separating the anal folds and requesting the patient to strain or bear down. The straining effort fills the external hemorrhoids with blood and causes them to stand out prominently and also brings the lower portions of the internal hemorrhoids into view. Digital examinations are not always reliable for, unless the piles have undergone inflammatory changes and become thickened, they frequently cannot be felt. Examinations with a speculum, especially if the patient is in the dorsal position, will usually show them. Patients are prone to call all rectal trouble hemorrhoids; hence all patients complaining of hemorrhoids should be subjected to a careful rectal examination in order to rule out other rectal conditions, especially cancer.

Palliative Treatment.—All mild cases and patients refusing operation may receive benefit through regulation of the bowels by changes in diet and the use of mild laxatives, thus preventing straining at stool. Drastic purgatives aggravate the condition and should be avoided. Internal hemorrhoids which have prolapsed and become strangulated should be reduced if possible. This is best accomplished by giving a hypodermic of morphin, applying a simple ointment and then gradually pressing upon the mass until the muscular action of the sphincter has been overcome. This will allow them to slip back past

the sphincter. The buttocks may then be held tightly together with adhesive strips to prevent a recurrence. After the inflammatory reaction subsides a radical operation should be performed. In case reduction cannot be effected the patient may be subjected to operation immediately or, if this is not accepted, may be given hot sitz-baths with local applications of soothing ointments or poultices. The following ointment, or one similar to it, is frequently used:

℞ Unguent. Gallae
Unguent Stramonii.....ãã 1oz.
Sig. Apply locally two to three times a day.

Radical Treatment.—External hemorrhoids seldom produce symptoms necessitating their removal except in instances when they become thrombosed and inflamed. Such a condition is best relieved by incising the tumor, turning out the clot and packing the wound with gauze.

Many methods have been suggested and used for the removal of internal hemorrhoids. At present three or four well tried methods are quite generally used. Formerly a method of injecting carbolic acid into each pile was frequently practised; at present it is seldom used. It carries with it certain elements of danger and is not to be recommended.

Preparatory preparation is the same in any of the operations chosen and consists of the administration of a purgative (usually 1 oz. castor oil) on the afternoon before the operation and an enema four to six hours before the operation in order to thoroughly cleanse the lower bowel. At operation the patient is placed in the lithotomy position. The buttocks are washed with soap and water and the sphincter slowly and thoroughly dilated with the fingers. The sphincter is then held well open and the lower rectum is washed by pouring water into it.

Clamp and Cautery.—This method is frequently used and when properly done is simple, safe and extremely satisfactory. The hemorrhoids are usually found distributed around the sphincters in three groups, one anterior and two lateral. The removal of the larger hemorrhoids from each of these three groups is usually all that is necessary in order to effect a cure, as any small hemorrhoids left undergo shrinkage as a result of the operation. The piles to be removed are seized with forceps and drawn down. A hemorrhoidal clamp, such as Smith's or Gant's, is then applied so as to embrace the base of the hemorrhoid, and a square sheet of asbestos is slipped between the clamp and the buttocks to protect the skin from the cautery. The hemorrhoids are

then slowly burned away with an ordinary soldering iron. It is safer to destroy the pile entirely by means of the cautery, and to avoid the use of a knife. The tissue is burned in such a manner as to produce a distinct ridge or stump of charred, thoroughly burned tissue. The forceps are then carefully slipped off and the burned area replaced within the sphincter. The other two hemorrhoidal areas are burned away in a similar manner, care begin taken to see that a small strip of normal mucosa is left between each of the areas burned. Six or eight punctures about ½ or ¾ in. deep are then made around the outer border of the sphincter with a small scalpel. This is done in order to allow the venous blood which will necesarily be dammed back in the region of the anus to escape and does much toward preventing post-operative pain and swelling. The ordinary soldering iron is better than the Paquelin or electric cautery. It furnishes a good body of heat and the heat is more easily regulated. Cauteries at red heat cut the tissues similarly to a knife and do not stop bleeding. The irons should be brought to a dull red and then allowed to cool slightly before using.

Ligation and Excision.—Perhaps the oldest of the usual methods and one which is frequently used is a modification of the well-known Allingham method of ligation and excision. By this method a large pile is seized with forceps and pulled down. With sharp pointed scissors the mucous membrane is divided at the lower pole of the hemorrhoid just at the juncture of the skin and mucosa. The incision through the mucosa is carried upward on each side of the pile. The scissors are then passed beneath the hemorrhoid, separating it from its muscular bed. The separation is continued upward until the pile remains attached only by a small pedicle composed of the vessels supplying it and a small strip of mucous membrane. The pedicle is now crushed, ligated with catgut or silk and the hemorrhoid cut off below the ligature. From three to four other hemorrhoids are similarly excised, care being taken to leave a strip of healthy mucosa between the hemorrhoids removed.

Whitehead's Operation.—By this method the entire pile-bearing area of the rectal mucosa is removed; it is not used as often as formerly, as it has been learned that practically all types of hemorrhoids may be safely cured by more simple methods. The operation is now usually reserved for the more aggravated types of hemorrhoids which have ill-defined borders and are associated with more or less rectal prolapse. The technic is as follows: Several large hemorrhoids are seized with forceps and pulled down. An incision is made completely around the

anus at the skin and anal mucosa. The mucous membrane is then separated with scissors from the sphincters on all sides. This separation of the mucous membrane is continued upward by blunt dissection with gauze and an occasional snip of the scissors, for a distance of 2 or 3 in. The object of the operation is to amputate the pile-bearing area and stitch the remaining edge of mucosa to the skin. This is done by dividing the mucous membrane transversely in front, for a distance of about ½ in. or more and suturing the edge of the divided mucosa to the edge of the skin with a continuous running suture of catgut. The division of the mucosa in segments of ½ in. or more is continued completely around the bowel and as each segment is divided it is stitched to the corresponding edge of skin. Many good sized vessels will be cut but these may be controlled by the running suture or by separate ligatures if necessary. The line of union of the skin and mucosa will lie outside the sphincter. The chief objection to Whitehead's operation is the possibility of subsequent stricture of the rectum through ulceration and non-union of the suture line.

Post-operative Treatment.—Some operators advise the use of a suppository, containing 1 or 2 gr. iodoform and ½ gr. morphin, immediately after the operation. Others place in the rectum, immediately after the operation, a rubber tube surrounded by gauze, claiming that this prevents hemorrhage, reveals any hemorrhage present and allows the passage of gases. Neither measure will be found necessary if the stab-puncture described under the clamp and cautery method is used. These punctures prevent the swelling which occurs about the anus when they are omitted. If pain is severe, morphin in ⅙ gr. doses may be given hypodermatically. The bowels are not moved until the morning of the fifth day when 1 oz. castor oil is given and when the patient desires to go to stool an oil enema may be used.

TUMORS OF THE RECTUM

Tumors of the rectum are usually classified into two groups, benign and malignant. Certain tumors are seen, however, in which it is impossible accurately to forecast the future and these form the connecting link between malignant and innocent growths.

Benign Growths.—Adenomas are the most frequent of the benign growths of the rectum. They may occur in both children and adults. They are usually small, 1 to 2 cm. in diameter, but may attain a diameter of 5 cm. or more; they may occur as single tumors but more fre-

quently are multiple and, at times, are seen in large numbers. Adenomas may be soft or hard, according to the amount of cellular or fibrous tissue present in them. At times they become cystic through the accumulation of mucous fluid, secreted by the epithelium lining the acini, which they contain. They may be irregular or smooth in contour.

Adenomas originate from the glandular tubules of the mucosa. When quite small, they appear as small wart-like projections on the mucosa. At this stage they are sessile, but as they enlarge, their bases become elongated and narrow. Later, probably because of the traction exerted by the bowel in its efforts to expel them, their narrow bases are still further stretched and form long pedicles. Upon section such pedicles are found to consist of blood-vessels, connective tissue and mucous membrane. When adenomas become pedunculated they are usually known as rectal polypi.

Microscopically, adenomas are composed of glandular tissue, a varying amount of stroma and blood-vessels and are covered with columnar epithelium. The glandular tissue found in these growths bears a marked similarity to that seen in the follicles of Lieberkuhn present in normal rectal mucosa. They usually secrete a mucus which differs only slightly from that secreted by the normal epithelium of the rectum. Various degrees of hyperplasia may be found in this epithelium. At times the hyperplastic cells closely resemble malignant cells and, in some instances, adenomas which have been removed have recurred as carcinomas.

Bleeding and tenesmus are the symptoms usually produced by adenomas. These signs may be entirely absent, however, until the tumor has prolapsed sufficiently to be protruded from the rectum during the act of defecation. It is then grapsed by the sphincter and has to be replaced. Rectal bleeding in children is nearly always dependent on the presence of these growths.

If the growths are within reach of an examining finger they may be easily recognized by digital examination. If their presence is suspected and digital examination fails to detect them, the rectum should be examined by a proctoscope. Rectal polypi may be easily mistaken for hemorrhoids.

Villous Tumors.—Villous tumors occur in adults, but are rarely seen. They appear as red, easily bleeding, lobulated growths with long club-shaped processes. They are usually sessile, but may be attached by very short pedicles. The tumors have a soft velvety feel

and at the same time give the impression of being tough and resistant. Villous tumors have a tendency to recur after removal and in this respect resemble carcinomas. They belong to the class of tumors which form the border line between benign and malignant growths. These growths may be distinguished from true carcinomas by the absence of fixation and induration of their bases and by the lack of friability which usually characterizes carcinomatous tissue.

Fibromas.—Fibromas are rare growths which are usually seen near the anal margin in adults. They have broad bases and, according to Ball, originate from thrombotic internal hemorrhoids which have become organized into fibrous tissue. Microscopically they are composed of dense fibrous tissue and blood-vessels and are covered with squamous epithelium. Fibromas usually do not produce symptoms except when they are long enough to interfere with the sphincter or when they prolapse.

Papillomas.—Papillomas, or warts, may occur in the skin around the anal margin. They are similar to the ordinary wart seen in other parts of the body and their etiology is not dependent on an associated venereal disease.

Condylomas.—Papillomatous new growths occurring about the anus during the course of venereal diseases or other chronic inflammatory diseases in this region are termed condylomas. These growths differ from the simple papillomas mentioned above. They are usually seen in two distinct varieties, the flat and the pointed condylomas.

Flat condylomas usually occur during the course of active syphilis and appear as small, flat, broad-based, slightly elevated growths of varying sizes. They frequently fuse together, producing tumors which may be either smooth or nodular and which may attain a diameter of 2 cm. or more. Microscopically they are found to be composed of connective tissue and blood-vessels and are covered with a thin layer of squamous epithelium. The irritating secretions present frequently destroy their epithelial covering so that ulceration and bleeding result.

Pointed condylomas are small papillomas which occur during the course of gonorrhœa or other chronic inflammatory disease which produces irritating secretions. They are frequently referred to as *venereal warts* and occur as multiple growths, in patches, around the anal margin. They are reddish brown in color, very fragile in structure and are attached by small pedicles. The extremities of the growths bifurcate and intermingle with the bifurcations of other nearby growths,

thus producing masses from 3 to 5 cm. in diameter, which are attached by many small pedicles. They are usually kept moist by the secretions of the disease with which they are associated and have a disagreeable foul odor. Pointed condylomas arise from the papillary layer of the skin and are distinctly benign in character. Microscopically they consist of connective tissue papillæ and blood-vessels and are covered by a thick layer of squamous epithelium.

Dermoids.—Dermoids are rare and usually occur on the posterior wall of the rectum. After the cyst-wall ruptures, they frequently discharge hair into the lumen of the bowel. Dermoids situated between the rectum and sacrum or coccyx are more commonly seen. These are known as post-anal dermoids. They may occur above or below the levator ani muscle. The growths occurring above the muscle may grow to be quite large and present as a tumor in the region of the coccyx.

Other rare benign tumors of the rectum, such as *lipomas*, *myomas*, or *fibromyomas*, *myxomas* and *angiomas* are occasionally reported. Lipomas usually have their origin from the fatty appendices of the upper portion of the rectum. They may project into the lumen of the rectum or they may remain within the pelvis. Myomas and fibromyomas originate in the muscular layers of the rectum. They also may project into the lumen of the bowel producing at times polypoid growths covered with mucosa, or they may grow outward toward the pelvic cavity.

Treatment.—Even when producing no symptoms, these new growths should be removed. The technic used in removing adenomas is practically the same as that used in operating for internal hemorrhoids. They may be drawn down with forceps and the tumor excised after ligating the pedicle or the pedicle may be held by a Smith or Gant pile-clamp and the tumor burned off with the actual cautery. Villous tumors should be excised with a fair margin of mucosa surrounding them, their bases burned and the edges drawn together with sutures. Flat condylomas are dependent on an associated syphilitic infection and disappear on treatment of this condition. Pointed condylomas should be cut away with scissors, their bases curetted and then cauterized with the actual cautery. Dermoids occurring in the rectal wall usually require partial excision. Those presenting in the region of the coccyx are cured by enucleating the cyst wall.

Exposure for such operations is best obtained by placing the patient in a reverse Trendelenburg position as is done in operating for malignant growths.

Malignant growths.—These may be divided into *epithelial growths* and *connective-tissue growths.*

Epithelial Growths—Adenocarcinomas are by far the more common of the malignant growths of the rectum. They have their origin from the epithelium lining the follicles of Lieberkuhn, or in diverticula. True diverticula of the rectum are not nearly so common as of the remainder of the large bowel. Nevertheless, as Telling has shown, they are not infrequently seen. Their pathological and surgical significance has been pointed out by Wilson and Giffin, who call attention not only to the inflammatory processes (diverticulitis and peridiverticulitis) which may arise therefrom but also to the occasional association of cancer therewith.

The cancerous cells usually retain the glandular characteristics of the epithelium lining the follicles and microscopically the tumor consists of an extensive growth of glandular tubules lined with cancerous cells. These tumors may be situated in any portion of the rectum but are more frequently located in the upper portion, near the sigmoid, or in the lower portion, near the anus.

Two rather distinct types of adenocarcinoma are seen. In one of these the growth increases in size in all directions and forms a distinct fungating tumor which projects into the cavity of the bowel. In the other, which is more frequent in carcinomas situated near the recto-sigmoid region, the growth spreads as a thin layer beneath the muscular and mucous coats of the rectum and has little tendency to involve the mucosa until late. Such growths usually extend more rapidly in a lateral direction and finally may almost completely surround the bowel and produce an annular malignant stricture. After the mucosa has become involved it breaks down and produces a bleeding cancerous ulcer. At such a stage the growth, upon examination may be felt as a crater-like ulcer with irregularly circular, raised and indurated edges. It is usually situated on one side of the rectal wall. The base and the tissues immediately surrounding the growth have a quite characteristic, hard, friable, indurated feel. In the annular type there may be almost complete stricture of the rectum. As the growth spreads, adhesions are formed to adjacent organs, such as the prostate, vagina or uterus and to the pelvic wall. Through necrosis or abscess formation fistulæ may occur between the rectum and surrounding hollow organs such as the bladder and vagina. The lymph glands in the hollow of the sacrum and those lying along the lumbar vertebræ become enlarged. This enlargement, however, may be caused

by septic infection and is not necessarily due to cancerous involvement. Later metastases occur in the peritoneum, liver and lungs. Occasionally, especially in the young, the cancerous cells undergo mucoid or colloid degeneration.

Cancer of the rectum may occur at any age but, like cancer in other organs, is seen more frequently after the age of 40. Males are more frequently affected than females. Its onset is insidious. The early symptoms are usually vague and may pass almost unnoticed. Persons affected usually attribute the symptoms first produced to hemorrhoids or constipation. For these reasons the disease is often fairly well advanced when first recognized. It not infrequently happens, also, that patients who have consulted physicians early in the course of the disease are carelessly examined and prescribed for and are allowed to go for months—possibly until the prospects for cure are lost—before the true nature of the disease is recognized. These facts should be borne in mind while attending all patients complaining of any rectal symptoms and a careful rectal examination should be made in order to rule out the possibility of a malignant condition.

The first symptoms usually complained of are a feeling of discomfort or fullness in the rectum. This is often associated with constipation and a frequent desire to go to stool. The bowel movements are unsatisfactory and to overcome this the patient resorts to the use of laxatives. This irregularity of the bowels may be associated with frequent attacks of diarrhœa (morning diarrhœa) during which the patient usually passes quantities of mucus. At times tenesmus is an early and marked symptom and during the straining efforts to evacuate the rectum a purulent blood-stained mucus is often passed. As the disease progresses the discomfort in the rectum increases to a dull heavy pain. This pain is usually increased by exercise and defecation and is often quite noticeable at night. Bleeding may be an early symptom but as a rule comes on later, after ulceration of the mucosa has occurred. The fæces then becomes streaked or covered with blood-stained mucus. If the growth is located high up near the sigmoid symptoms of chronic obstruction with colicky-like pains may be marked and may appear early in the course of the disease. Late in the disease the pain becomes constant and severe and the patient complains of much gas. Secondary symptoms such as emaciation, anæmia, digestive disturbances or œdema of the legs appear. At times metastases occur in the liver and give rise to a nodular enlargement of this organ. Should the wall of the bladder become involved, vesical tenesmus occurs and

should fistulæ develop between this organ and the bladder, fæces and gases may pass through the urethra. At this stage, stenosis of the bowel or perforative septic peritonitis may occur.

Patients allowed to go without operative treatment usually succumb to the disease within two or three years after the onset of symptoms. This time may be extended to a longer period, however, and depends largely on the age of the patient, type of growth, etc. It is usually more rapidly fatal in young persons, who sometimes die in less time than one year. The soft fungating growths seem more rapidly fatal than the annular type of growth.

Carcinoma situated in the ampulla may be diagnosed by digital examination. If higher up, the use of the proctoscope will be necessary. In either instance it is advisable, before subjecting the patient to a radical operation, to submit a small portion of the growth to a competent pathologist for microscopic examination. It must be borne in mind that cancerous tissue is quite friable and care should be exercised while making digital or proctoscopic examinations to prevent rupturing the bowel-wall and thus causing septic peritonitis.

Epitheliomas.—Epitheliomas occur much less frequently than adenocarcinomas and are similar to epithelioma occurring in other locations. These growths originate from the squamous epithelium lining the skin near the anal margin. They may begin as wart-like growths which slowly increase in size and develop a hard indurated base or as an ulcer, which becomes crater-like in character and develops a marked induration of its edges and base. These growths may involve only a portion of the anal margin or may entirely surround the anal orifice. They tend to invade the skin surrounding the anus rather than the lumen of the bowel, but may involve a portion of the anal canal. As a rule, they bleed little but are quite painful and may be associated with a watery discharge. Microscopically like epitheliomas seen elsewhere they are composed of invading columns of epithelial cells and numerous epithelial pearls. Metastases are not common, but when present are usually in the superficial inguinal glands and occasionally occur, through invasion of the perineal tissues, in the pelvic glands.

Connective-tissue Growths.—Sarcoma of the rectum is a rare disease. It may occur either as a primary growth or as a metastatic growth from sarcoma located in the pelvic organs or elsewhere in the body. Several types are seen and these vary in their malignant characteristics. The spindle celled sarcoma is usually more mildly malignant and recovery

may follow its complete removal. On the other hand lympho sarcoma and melanotic sarcoma are very highly malignant and are rapidly fatal.

Clinically, sarcoma frequently closely resembles carcinoma and a diagnosis usually can be made only after the removal of a specimen. Sarcomas usually occur in the submucous layer and are most frequently seen in the lower segment of the rectum. They usually form longitudinal masses and, though they may project into the lumen of the bowel, do not, as a rule, tend to produce stenosis. When seen early the mucous membrane can usually be moved over the tumor.

Lymphosarcoma may be seen in connection with similar growths occurring in other portions of the intestinal canal. They are extremely malignant.

Melanotic sarcomas are the more frequent of the primary sarcomas of the rectum. Many of the cells composing these contain pigment. They spread both by the lymphatic and the blood streams, and produce similar metastatic growths throughout the organs of the body. They are extremely malignant and removal is of no avail.

Treatment.—Many advances have been made in recent years in the surgical treatment of malignant growths of the rectum. The great drawbacks to radical operations in this region have always been the refusal on the part of the patient to submit to operations involving the possibility of a loss of sphincter control and their abhorrence of an artificial anus. Surgeons, in their efforts to prevent such, were prone to perform operations which were not sufficiently radical to prevent recurrence. However, patients are now learning to look upon an artificial anus in the light of being the compensation or price which must necessarily be paid for the chance of a cure of the disease.

Radical operations in which the sphincter muscles are preserved are done at a greater risk to the patient and the sphincter control is often poor and inadequate. Fagge has also proved that, contrary to our former beliefs, carcinoma may travel downward into the lymphatics of the anal canal without producing visible signs of anal involvement. These facts have gradually led surgeons to sacrifice the sphincter muscles with much less hesitancy.

It has also been demonstrated that the great majority of operative deaths are due to sepsis (90 per cent. according to W. J. Mayo) and that a preliminary colostomy performed some days before the radical operation not only greatly diminishes the chances of such fatal sepsis but allows a thorough exploration of the entire abdominal cavity. Such an exploration is of great importance in deciding whether or not the con-

dition is an operable one and often prevents patients, with already existing hopeless metastases in the liver or peritoneum, from being subjected to a radical operation for a local removal of the growth.

Various methods have been used for removal. Operations through the anus or vagina may occasionally be used or the disease may be attacked by perineal or sacral operations. Frequently also a combined abdominal and perineal or sacral operation is used.

Occasionally small, early carcinomas may be locally excised and cauterized through a dilated sphincter or a small growth situated on the anterior wall of the rectum may be removed by an incision through the posterior vaginal wall. Such instances are, however, rare.

Cripps' perineal operation or some modification of it may be used in low growths involving the anal canal. Such growths are frequently epitheliomas. By this method the growth, with a good margin of skin about the anus, the sphincters, the anal canal, a wide margin of fat, and a sufficient amount of the ampulla of the rectum are removed. The walls of the rectum may then be loosened and pulled down far enough to allow them to be stitched at a much lower level or the rectum may be left undisturbed. In either instance bougies should be used after three or four weeks to prevent contracture.

In all growths involving the anal canal, the inguinal glands on both sides should be removed.

The sacral route is the method originally devised by Kraske, but has been subjected to many modifications. This type of operation or some modification of it is the operation of choice at present and is perhaps the most universally used. By this method the coccyx and a part or the whole of one or two segments of the sacrum are removed. The sphincter muscles may be left and the proximal end of the bowel pulled through them after resection or they may be sacrificed and a sacral anus made. The route is also frequently used after a preliminary inguinal colostomy and in the combined abdominal and sacral operation.

After using various modifications of the method the following two-stage operation has been found most satisfactory. This operation carries with it a smaller operative mortality, a higher percentage of cures and gives the patient an anus more easily controlled than any other method.

First Stage.—A preliminary permanent colostomy is made through the left rectus muscle by the Lilienthal method or through a gridiron incision by the Littlewood method. The abdominal cavity is examined for metastatic growths and the tumor to be excised is palpated as to

fixation, etc. The bowel is opened with a cautery 24 to 72 hours later. The lower segment is irrigated thoroughly each day.

Second Stage.—Ten to twelve days later the entire rectum including the sphincter muscles, perirectal fat and glands are removed by the sacral route.

The patient is placed in a reversed Trendelenburg position, *i.e.*, face down instead of lying on back. The anal canal is closed with a linen suture. A median incision is made from the middle of the sacrum to the anus and then around the anus.

The two lower segments of the sacrum are divided with a chisel and these, with the coccyx, are excised. No effort is made to preserve the sphincter. The anal canal, sphincters, rectum, fat and glands are then separated up to the peritoneum. This is opened and packed with gauze. The sigmoid is pulled down, the inferior mesenteric artery ligated and the bowel clamped and divided above the disease. The stump is sterilized with cautery and turned in. The abdominal pack is removed and the peritoneum is stitched to the bowel. The wound is drained and loosely closed with silkworm-gut.

Sarcoma.—The treatment of sarcoma is practically the same as that of carcinoma. Melanotic sarcomas and lymphosarcomas are so rapidly fatal that operative interference is of doubtful benefit. Spindle-celled sarcomas are occasionally removed with good results.

Some benefit has been derived from the administration of Coley's serum (a mixture of the toxins of the streptococcus of erysipelas and Bacillus prodigiosus), and following operation, patients should be given the benefit of its use.

Good results have been reported following the use of radium, but at present the value of this remedy is strongly questionable.

Patients with inoperable growths frequently receive much benefit through a permanent colostomy.

Pruritus Ani.—This affliction may occur as an accompaniment of such constitutional diseases as gout and diabetes, or in association with hemorrhoids, fistulæ or fissure. It may also occur as a disease by itself. In the beginning of the trouble a small patch of skin in the folds just outside of the anal ring is usually affected. The first symptoms are a little burning and itching. These rapidly increase and continue day and night until the sensation is unbearable. The little eczematous patch of skin gradually spreads and encircles the entire anus and sometimes spreads out on to the thigh and scrotum. The skin becomes much

thickened, dry and hard. The suffering is most intense and the individual may develop serious reflex conditions.

Treatment.—A great many procedures, both medical and surgical, have been tried for the relief of pruritus. Most of these have been only partially successful or have been complete failures. Any constitutional difficulties must be recognized and treated. Existing hemorrhoids, fistulæ and fissures must also be remedied. Painting the skin repeatedly with compound tincture of benzoin will sometimes give relief. Cauterizing the affected area or excising and skin grafting have been done, though they do not insure a cure. Assuming that the condition may be due to sensory nerve disturbance, several methods have been devised to destroy the nerves. Incisions made at the borders of the affected area and dissecting underneath the skin between these incisions have given relief. The sensory nerve may be destroyed by injecting, superficially, small quantities of alcohol.

Prolapse of the Rectum and Anus.—Prolapse of the anus occurs in two different forms. In one form it is associated with hemorrhoids and is seen more often in adults and the aged. In the other form, more often seen in children, the anal mucous membrane is pushed out in a ring. These types of prolapse are often spoken of as incomplete; the prolapsing is caused by a slipping of the mucous membrane and there is no extrusion of the other coats of the bowel. When all the coats of the bowel are protruded, it is spoken of as complete prolapse or *procidentia recti.* This may vary in degree from a small rosette to a prolapse several inches in length. In most of the cases that are at all extensive the normal peritoneal covering of the upper part of the rectum is pulled down as a pouch into the prolapse. This pouch frequently contains other abdominal viscera such as loops of small intestines, omentum, at times the ovaries, tubes and uterus.

The principal supports of the rectum are the levator ani and sphincter muscles. Any tendency to weaken these supports may be the cause of the prolapse. Prolapse is very apt to come in children weakened by long illness, especially if there has been repeated and prolonged straining as might occur in diarrhœa, rectal polypus (Fig. 114) or worms. Great strain brought upon these muscles by coughing during an attack of whooping cough or severe bronchitis will sometimes stretch them enough to produce prolapse. This is especially true if the child's general health is below normal and the fatty supports in the pelvis have greatly diminished. It is sometimes thought that procidentia is brought about in young children by allowing them to sit upright and strain in an effort

to move their bowels, or by allowing the child to sit at stoola fter the bowel has been emptied. In adults, prolapse is more often seen in elderly people. In men it frequently is associated with constipation, hemorrhoids, rectal polypus, enlarged prostate and stone in the bladder, and occurs most often when they are weakened from other causes. It is seen occasionally in men who are otherwise strong and in whom no exciting cause for the condition can be found. In women the prolapse is often associated with prolapse of the uterus and vagina. The prolapse in adults is usually of the complete variety. The lesion usually

FIG. 114.—Incomplete prolapse, showing two polypi.

comes on gradually, starting as a mere turning-out of the anal canal. This protrusion of mucous membrane gradually increases and the incomplete prolapse is converted into a complete one by a dragging down of the muscular coats. In the early stages when the prolapse is slight there may not be a great deal of inconvenience. The extruding part will usually have to be reduced after each bowel movement. As the prolapse increases, there is apt to be great suffering and often inability to keep the bowel in place except when lying down. In the extensive cases the mucous membrane becomes markedly thickened and thrown into folds. The bowel opening is at the apex of the cone of the protruding part. The mucous membrane at the base is continuous with the skin at the margin of the anus. The hypertrophied mucous membrane is covered with mucus and oozes when it is touched. It is often very

difficult to reduce the prolapsed bowel because of swelling and œdema in the tissues. If the prolapse persists for any length of time, there may be ulceration of the mucous membrane and sloughing.

Treatment.—Many of these cases, especially in children, can be completely cured by relieving the cause. Constipation especially should be relieved, and it may be necessary to use laxatives for some time. Many advise the giving of cold water enemas after each bowel movement and also mild stimulants to add tone to the weakened muscles. Children should be made to defecate while lying on the back or side. A prolapse in a child is usually best reduced either by holding the child up by his feet or by having him lie across the nurse's knee with his head down. The protrusion is well anointed with vaselin and is reduced by gradual pressure. It may be held in place by one or two adhesive straps across the buttocks, which should be left in this position for some time. It will be necessary to remove them each time the bowels move. By treating a prolapse in this way and gradually relieving the etiologic factors practically every case of prolapsus of the rectum in children can be cured. It is seldom necessary to operate on them. In adults it is usually necessary to operate in order to effect a cure. If the prolapse is incomplete and is associated with hemorrhoids, as it often is, cure will be effected by removing the hemorrhoids, catching in the clamp with each hemorrhoid a little of the protruding mucous membrane. Many operations have been devised for the relief of complete prolapsus in adults. Probably the one most used and which is usually satisfactory is amputation of the protruding part. In doing this, we must bear in mind that the peritoneal cavity will probably be opened and that a loop of small intestine or other viscus may lie in the prolapsed peritoneal pouch. Great care must be taken not to soil the peritoneum or injure anything in the cul-de-sac. Among some of the older methods were operations to strengthen the sphincter muscle by the introduction of a circle of silver wire. A procedure which has been successful in some cases is to expose the rectum through a posterior incision extending from the tip of the coccyx to the sphincter muscle and to fix the loose flabby tissue of the rectum by sutures to stable portions of fascia and ligament. Some methods include folding of the wall of the rectum and also tacking up the lax levator muscles. Several methods of operating through the abdomen have been described. The pelvic colon may be pulled up and its mesentery attached to the wall of the pelvis by several sutures. This has been satisfactory in some cases, though there have been many relapses. Another method is to pull up

the pelvic colon and anastomose it as high as possible to the descending colon (McArthur).

Pilonidal Sinus or Post-anal Dimple.—A distinct dimple or shallow depression over the tip of the coccyx may be found in about 5 per cent. of all adults and in from 20 to 30 per cent. of all infants. This dimple is of no particular importance except when it develops into a sinus which in turn becomes a cyst-like cavity filled with epithelial detritus and hair. This sinus is usually formed by a retraction of the integument and is, therefore, lined with true skin which contains hair and sebaceous and sweat glands. In some instances the sinus communicates with the spinal canal and is lined by cylindrical or ciliated epithelium. It is then termed a sacrococcygeal fistula. There is usually a persistent offensive discharge, especially if infection is added.

At times there is considerable difficulty in distinguishing the post-nidal sinus from the anorectal fistulæ, though the location of the sinus in the midline in the region of the tip of the coccyx and the presence of protruding hair usually makes the diagnosis clear.

There are no symptoms until the sinus becomes infected and an abscess forms. Most of these patients come for examination complaining of repeated abscess formations.

The *treatment* consists in the complete removal of the track of the sinus together with a considerable part of the surrounding subcutaneous tissue. The sinus is prone to recur even after a wide excision, probably because a small branch of the sinus or piece of the sac was not removed.

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SECTION IX

LIVER

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Surgical Anatomy.—As in the case of the stomach, the X-ray demonstrates that the liver, in the erect posture, occupies a much lower position than the older text books of anatomy, based on dissections of the prone cadaver, formerly taught. Not infrequently, particularly in the female, the anterior margin of the right lobe can be seen through the fluoroscope at the level of the anterior superior spine. The old impression, gleaned from the diagrammatic plates, of a gall-bladder hanging downward must likewise be corrected. It lies with its long axis more nearly antero-posterior, while the organ as a whole is far more mobile than the older anatomists taught. Like the stomach, spleen or kidney, the liver shifts with the varying positions of the patient. Advantage should be taken of this in surgical procedures, since it may be lifted partially out of the abdomen through the incision as well as displaced forward by flexion of the operating table, or by properly placed sand bags (Fig 115). When its suspensory ligaments become too elongated "wandering liver" results, for which many operations have been proposed; these will be referred to elsewhere.

Injuries of the Liver.—*Hemorrhage.*—Injuries of the liver may be of every conceivable type: lacerations, tears with or without external wounds, stab and bullet wounds, etc.; hence no fixed method of treatment obtains and the surgical indications must be met as they arise. Among these indications, hemorrhage is by far the most important. It may be evidenced by escape of blood through the external wound, or, in absence of a wound, by the recognized signs and symptoms of internal bleeding. When the hemorrhage is too pronounced to permit waiting, surgical interference should be instituted. With the abdomen open, it should be remembered that complete, immediate and positive stasis of hepatic hemorrhage may be obtained by compression of the vessels entering the liver. This can be accomplished by grasping them

between the thumb and fingers. The assistant, standing on the left of the patient, inserts his left index and middle fingers through the foramen of Winslow and with his thumb compresses the vessels crossing them. During the entire operation the bleeding is controlled at

FIG. 115. Illustrating the lifting forward, through the wound, of the liver by an assistant who grasps the same by a broad contact; using loose gauze enables him to hold the liver more securely. In many cases it is thus feasible to bring into view the gall-bladder with its termination in the common duct and inferior surface of the liver. With such an exposure any necessary surgical interference can more readily be made.

will; the spurting points are readily found for ligation, and oozing is prevented when necessary by simple gauze packing. McDill's modification of this control by a temporary stab puncture through the

right lumbar muscles and the substitution of a pair of intestinal clamps for the fingers gives added room and leaves the assistant free for other work. The entire hepatic wound can be, so far as feasible, re-

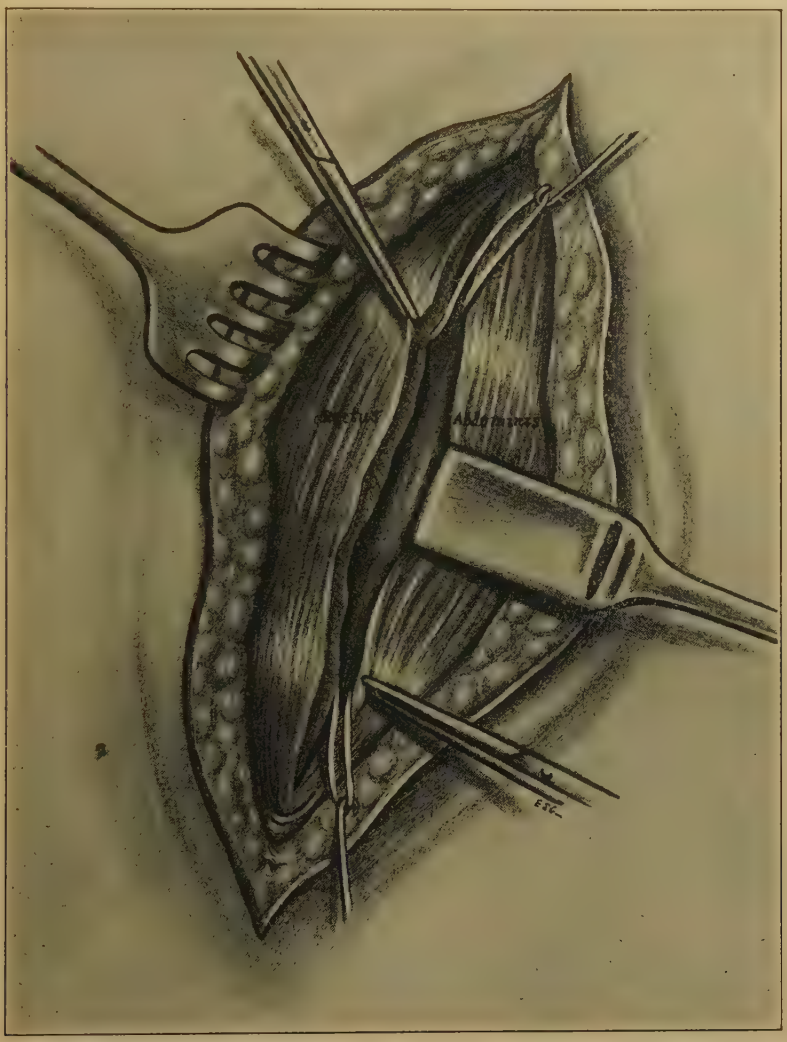

FIG. 116.—Illustrating schematically the first step in the right rectus incision with the innervation to same crowded by blunt dissection to either end of the wound.

paired before removal of clamps. Opening of the latter from time to time determines the success of the hemostasis. Resections of liver have been made by the writer with this control.

A definite method of surgical access to the liver must be selected with

relation to the exact trouble existing when that is possible of determination; otherwise the right rectus perpendicular incision will prove the most generally useful (see Fig. 116). When surgical interference with the *left* lobe is determined upon, advantage is taken of the anatomical fact that it lies in contact with the abdominal wall without the intervention of the costal cartilages and hence can be approached

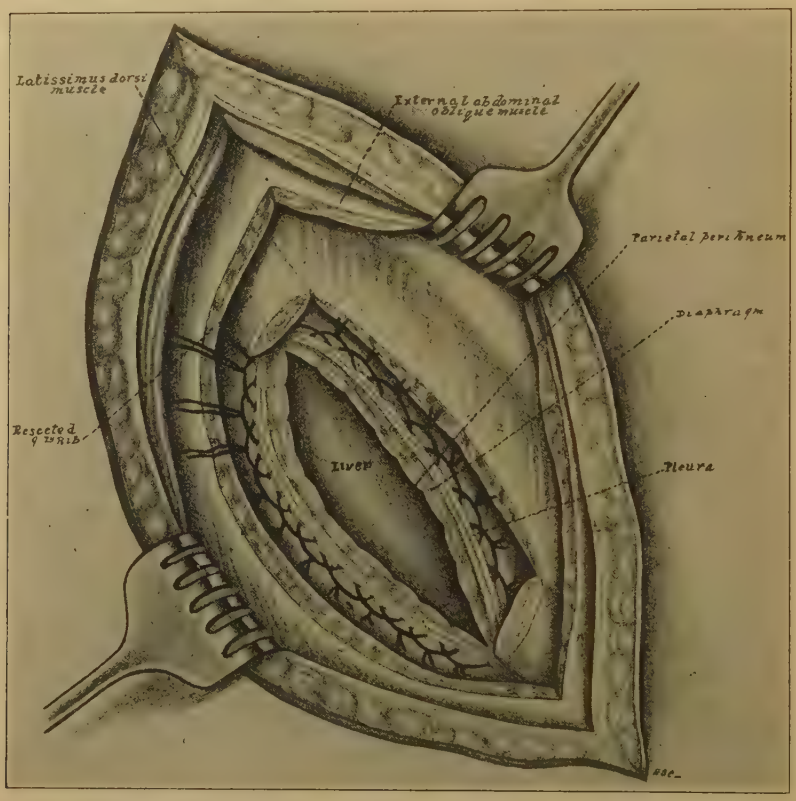

FIG. 117.—Illustrating McDill's suture of the costal pleura to the diaphragm after careful subperiosteal resection of one or more ribs and prior to any incision of the tissues lying between the two rows of approximation stitches.

through the outer third of the left rectus, the incision following somewhat the costal margins. When the upper convex surface of the right lobe is to be explored, the transpleural route should be selected. This necessitates the resection of two or more ribs in the anterior axillary line. McDill (Surgery, Gynecology and Obstetrics) has greatly improved the technique of this procedure by rendering improbable the chief danger, septic pleuritis. He makes an immediate suture of the parietal

and diaphragmatic pleural surfaces *after* a careful subperiosteal removal of the necessary ribs (see Fig. 117). By this means, too, a right pneumothorax is avoided. Incision is then made through the diaphragm thus exposed. This brings the convex surface of the liver into

FIG. 118.—Illustrating the transverse incision of the posterior sheath of the rectus (transversalis muscle and peritoneum) for access to the palpable and distended gall-bladder. It conserves the entire innervation of the transversalis muscle and its respiratory function. With the dropping back of the gall-bladder, its separated margins fall back into position and can be easily sutured.

view, and at the same time opens and drains any existing right subphrenic abscess.

Immobility of the costal arches forms a serious obstacle to exposure of the liver through the abdomen but these arches can be rendered mobile by a perpendicular section of the transverse fibrous structures (sheaths of the recti) that bind them together, and thus access to the

liver becomes easy. It is important, therefore, to carry the abdominal incision *high enough* (to ensiform if necessary) to permit of retraction of the costal arch and it does not matter whether this incision be situated in the mesial line, mid-rectus sheath or at the outer edge of the rectus. When the incision has been extended downward 2 in. below the liver margin, added room with less paralysis of the abdominal wall can be obtained by extending it horizontally to the right. Preservation of the greater part of the rectus belly to the right of the incision through its sheath will leave a better subsequent tone to the upper abdominal wall *When the gall-bladder is frankly* the seat of the surgical trouble for which operative interference is being made, the writer cannot too strongly emphasize the advantages obtained by incising the posterior sheath *transversely* at the proper level, since it preserves intact the tendinous fibers of the transversalis muscle and prevents a future hernia by converting the ordinary perpendicular incision into a muscle-splitting operation that gives ample room for any work on the gall-bladder and in the writer's hands has been most satisfactory in the ease of primary closure and absence of future hernia or even bulging of the scar (see Fig. 118). Suture of the posterior sheath when the perpendicular incision has been used is often most difficult, while the reverse is true of the transverse separation of the fibers of the transversalis which constitutes the posterior sheath of the rectus. This incision can most readily be extended to any length desired, and with the removal of the retractors its edges immediately fall into contact.

Liver Abscess.—Because of the unique blood supply of the liver and the potential invasion of its excretory ducts it is peculiarly exposed to infective processes. The great majority of these occur through the portal stream, the minority through the bile ducts, a few through the nutrient artery. Coming from the bacteria-laden intestinal tracts the portal circulation frequently carries infective elements to the liver. In health, when moderate in number and mild in virulence, these are readily disposed of by the liver cells or are eliminated with the bile. When in excessive number, or of too great virulence, abscesses result. Lesions of the intestinal mucosa whether ulcerative in character, as in typhoid or tuberculosis, or destructive as in dysentery, too frequently form atria of access to the portal circulation and thence to the liver. Even the appendix, through its veins, supplies a source for pylephlebitis and abscess. Again, through the bile tracts we find the liver substance invaded by those intestinal parasites capable

of self propulsion; among such the amœba and the distoma-hepaticum figure most prominently. Working their way along the bile tracts, the normal flow in which has been retarded by some febrile process, similar to that seen in the parotid in typhoid, they carry with them the pus-producing bacteria of the intestine, hence the amœbic abscess, dysenteric abscess, distoma abscess. For these reasons such abscesses are often multiple. The splendid opportunities for observation accruing to the medical departments of the United States Army both at Panama and Manila have forever disproven the older teachings that liver abscess is generally single, usually in the right lobe and curable by simple drainage. Both operative interference and careful post-mortem studies of those dying in spite of drainage of the principal cavity, showed the unsuspected frequency of other smaller pockets. The writer has personally examined such pathological specimens at Panama, and learned that the Department's statistics of liver abscess during the last two years of the canal construction were most favorably influenced by the careful search for and finding of other abscesses at the time of operation. Occasionally the infective emboli are not so numerous as to make multiple miliary abscesses. Hopeless as multiple hepatic abscesses may seem, the writer has saved one with an autogenous vaccine made by the culture of the contents taken from one of the many pea-sized abscesses seen on the surface of a liver exposed for suspected simple abscess. The infection (pure colon bacillus) had followed a clamp and cautery operation for hemorrhoids.

Abscesses of liver untreated by operation may rupture (1) externally, (2) into a bronchus, (3) into hollow viscera, (4) into the peritoneum; hence the line of attack will in part be determined by the symptoms, and that incision chosen which will give the best access to the pus.

The chocolate colored pus of a true liver abscess (not suppurating cyst) composed as it is of leucocytes, red blood corpuscles, liver cells and bile, once seen is never forgotten. Since the destructive changes are sometimes very extensive, there is occasionally observed a biliary fistula remaining at the point of drainage. The rarer infective elements, like actinomycosis, are occasionally present. The superficial abscess is not difficult of diagnosis, but a small centrally located abscess may tax all the skill of the best clinicians. Here, sensitive peritoneal surfaces are not yet involved; hence there is no pronounced pain and little tenderness. Changes in liver size are not apparent. Since the products of bacterial digestion of liver substance contain peptones, such can usually be found in the urine. Similarly, the bile tracts,

large and small, destroyed by the bacteria, leak bile into the abscess cavity; thence through the blood it is carried to the urine. External biliary fistulæ sometimes form the terminal stage of large hepatic abscesses. The liver, spleen or brain may conceal the "cryptic, or silent zones" of suppuration; hence every instrument of precision, every scientific test should be applied in order to justify exploration of the most probable focus. Exploratory puncture is permissible only after every necessary preparation has been made for an immediate laparotomy. If positive, the needle should *not* be withdrawn, but left *in situ* until the abdomen has been opened and the area of needle entrance protected against peritoneal infection. Under such precautions several *negative* punctures can be made with reasonable safety to the patient and may determine the line of surgical attack.

The abscess, having been found, should be emptied of the greater part of its contents by aspiration. Then an opening only large enough to permit the introduction of an appropriate drainage tube should be made. When feasible, the tube should emerge by a stab puncture through that portion of the belly wall which lies or will lie most nearly over the opening into the liver abscess. Peritoneal soiling during the first days should be prevented by strips of folded gauze packing carried down to and walling off the opening in the liver capsule.

Gummata of the Liver.—Gummata of the liver are sufficiently frequently met with by the surgeon to be worthy of mention here, though not to be considered in themselves a surgical ailment. They are discovered in the exploratory laparotomy made for obscure liver affections in which lues had not been suspected. They are, when producing symptoms, associated with persistently recurring afternoon chilly sensations, moderate fever, low leucocyte count, subicteric hue, and a general malaise unyielding to any but specific treatment. They are characterized, when exposed, by nodes of very variable size of light yellowish color and associated usually with the puckered cicatrices of older healed lesions. A thickened black inspissated bile is usual in the gall-bladder of such a case. The above features clinically distinguish gummata from neoplasms. Naturally the Wassermann and Noguchi luetin test will aid. The writer has secured relief from coincident ascites by means of the Talma-Morison operation, combined of course with antiluetic reatment, in cases in which the livers presented characteristic gummata with cicatrices.

Hydatid Cysts.—Hydatid cysts of the liver abound in those countries in which the dog comes into close domestic relationship with his master,

hence is seen among the Esquimaux, the sheep herders of Australia and the cattlemen of the Argentine. The few cases seen in our clinics serve chiefly as a stimulus to our diagnostic acumen. Usually, but not always single, hydatid cysts manifest their presence by their (1) mass, (2) physical characteristics, (3) toxins, (4) blood changes, (5) proneness to infection or rupture.

1. According to the location of the cyst its *mass* influences the contour of the diaphragmatic dome by pressing upward; it may alter the outline of the free border of the liver by pressing downward or by dragging downward as may be the case when it develops largely outside the liver and projects even into the pelvis. Mass pressure on the veins about and in the liver may give rise to venous dilatation and transudates similar to those observed with neoplasms in this region. The chest or abdominal walls may yield in contour to their pressure.

2. When young and *uninflamed* the tension in the cyst is usually sufficiently low to permit a sense of fluctuation on palpation, in which act a peculiar thrill, the hydatid fremitus, can sometimes be detected. In older cysts and those that have had periods of inflammatory reactions with consequent thickened calcareous walls and chitinous capsule, the tension may be so great as to give the impression of a solid tumor.

3. *Toxins* produced in the normal growth of the parasite may gain access to the general circulation in sufficient quantity to produce such symptoms as urticaria, nausea, etc., and like those of other parasites stimulate a pronounced increase in the eosinophiles.

4. *Infections* of these cysts are extremely common though whether the infections are hematogenous or ascend through the bile ducts, is not known. In fact this infection may be the first symptom to attract the attention of either patient or surgeon.

5. *Rupture.*—Though the growth of hydatid cyst is slow, often consuming years, yet if infection is escaped, their tendency is ultimately to rupture, the manifestations being dependent upon the point of rupture. As in hepatic abscess, rupture may take place in any direction, into any hollow viscus, into the pleura, the peritoneum or through the chest wall.

Since the hydatid cyst is most frequently discovered because of a suppurative process in it, the treatment differs but little from that of hepatic abscess with this exception that whenever feasible an effort should be made to remove the chitinous capsule lining. When the line of cleavage between the chitin and the ectogenous fibrous covering is found, the former can usually be peeled out with ease. When it

is found impossible or inadvisable to remove the sac, it should be marsupialized.

Tumors.—Tumors of the liver, aside from the cysts already referred to are rarely primary, hence are of limited surgical importance. Occasionally, however, they are so situated at the free margin of a lobe, or are so pedunculated as to be successfully removed even when they are the result of direct contact invasion from a primary stomach or primary gall-bladder carcinoma. The writer has demonstrated, three years after operation, the success of resection of such tumors through the neighboring healthy liver substance. Temporary control of the entire hepatic circulation by the fingers of an assistant compressing its vessels at the hilus or (after the suggestion by McDill) by an intestinal clamp, renders the operation bloodless. Large portions of the liver can be removed without serious interference with vital functions. Laboratory experiments go to prove that there is often, as in the thyroid, an hypertrophy of the remaining portion. The prevailing fear of excessive hemorrhage has been proven to the satisfaction of the writer to be groundless.

Cirrhosis.—Surgical interference for the ascites incident to obstruction in the portal hepatic flow is restricted largely to alcoholic cirrhosis though other varieties have also yielded to the Talma-Morison operation. Success can be expected only in the more moderate degrees of cirrhosis, but in one very desperate instance the writer has had a radical cure. More is to be hoped for in the artificially created lymph spaces adapted by McDill from the work of Handley on œdema of the arm after axillary carcinoma. He inserts into the peritoneal cavity the ends of long silk strands through the trochar used to tap the abdomen, and with a long needle-pointed probe carries the other ends for a distance of 6 to 10 in. in the areolar tissue beneath the skin leaving them permanently buried. Acting like lamp wicks, there is established a permanent leak into the subcutaneous tissues, with a consequent reduction to a minimum of ascitic fluid. An equilibrium is established and the patient relieved by a procedure far less dangerous than any yet devised. The writer after operating upon a patient suffering from alcoholic cirrhosis with ascites complicated by an acute gangrenous appendicitis with high fever and the presence of cloudy offensive ascitic fluid, etc., has seen the spontaneous cure of the ascites follow, because of the extensive adhesions provoked by the Mikulicz gauze drain inserted at the time of operation through a muscle-splitting incision over the appendix.

Surgical Anatomy of the Gall-bladder.—Leaving to the works of descriptive anatomists all questions of general minute anatomy of the gall-bladder, attention will be called only to a few practical points of use to the surgeon. Its *position* is so variable that no fixed point can be given as to the location of its "fundus," the only part of the gall-bladder ever palpable. Clinically, its position is somewhat determined by the figure of the patient; in the large flabby plethoric belly it lies to the right of the outer edge of the rectus; in the slender corset constricted figure, to the left of the same, at the level of the ninth or tenth cartilage. Under pathological conditions the variations in position are exceedingly wide; it may disappear almost entirely, or become so distended and elongated as to reach to the false pelvis. If the direction of the *sigmoid* curve of its cystic duct be borne in mind, some comfort will come to the operator endeavoring to pass a probe through it, or in trying to dislodge a small impacted calculus. Not infrequently the *apparently wrong* direction for dislodging the stone thus impacted is the correct one and is first *toward* the common duct, then *from* it. The fact that the pancreatic duct joins the common duct just prior to its emptying into the duodenum is of decided surgical moment, since a stone lodged here, even when of pancreatic origin, can provoke all the symptoms of common duct stone, or *vice versa*, the arrested common duct stone in this position may provoke an acute pancreatitis, or its removal cure the same.

The gall-bladder lies in contact with the hepatic flexure of the colon, the duodenum and the pylorus, hence perforation into either of these may occur. A proper appreciation of the Morison pouch bounded by these organs plus the liver, and the knowledge that an efficient drainage of the same either anteriorly through the surgical incision, or by a stab wound through the lumbar region, will protect the patient efficiently against a generalization of a local peritoneal infection. A considerable accumulation of fluids from a leaking gall-bladder, or perforating duodenal ulcer may collect here before the dam offered by the colon and duodenum is overflowed.

Injuries to the gall-bladder, whether by stab, bullet or other mechanical violence, must be treated according to the surgical indications to which they give rise. Suture of such a ruptured gall-bladder is a safe and almost always successful procedure, as is the suture after intentional opening of the non-inflamed gall-bladder for stone. The chief sign of rupture of the gall-bladder is the appearance of a jaundice associated with a rapidly increasing collection of fluid in the abdomen.

This, following the immediate shock always accompanying the escape of any fluid into the peritoneum, whether blood, bile, ruptured cyst or the contents of any hollow viscus, makes itself evident in the first 24 to 48 hours.

If the escaped bile be aseptic, little or no peritoneal irritation will be provoked; if septic, peritonitis promptly ensues. Differential diagnosis between injury of the common duct with its large branches and the gall-bladder cannot be made except by operation; hence any trauma in the gall-bladder region whether direct or indirect, associated with the above conditions justifies early surgical exploration.

Anomalies of the gall-bladder are chiefly the result of preceding pathological conditions. One congenital, or acquired anomaly, which the writer has observed and has not as yet seen referred to in the literature, is worthy of mention. Occasionally the fundus is quite elongated, projects well below the hepatic margin and in certain positions folds up over that margin between the liver and the costal cartilages. This may result from corset constriction in the female in which sex it is more often met with, but it is also seen in the male, producing colicky symptoms resembling so closely biliary colic as to justify exploration. In the writer's case no stones were found and no cholecystitis, only this elongated flap-like folding of the gall-bladder on itself between the ribs and liver. Further recurrences of the attacks have been prevented, by invaginating, after opening the fundus, with a purse-string suture in much the same manner as the stump is buried in appendectomy.

Biliary Colic.—Those intense pains incident to the efforts of the musculature of the bile tracts or gall-bladder to force along their lumen masses too large to pass readily, whether these masses be gall-stones, clots, or thickened mucus, are sometimes so severe as to in themselves jeopardize life. One patient of the author expired in an agonal attack of colic. Careful post-mortem revealed a stone half delivered through ampulla into duodenum. No other pathological lesion was discoverable.

When a stone is engaged in the cystic duct, the pains are referred to the back and right shoulder blades; when in the common duct, to the epigastrium and back. A clinical demonstration of the relation of the right shoulder-blade pain to the cystic duct was first made by Dr. Frank Billings. Introduction through a biliary fistula into the cystic duct of a Nélaton bullet probe would invariably provoke a typical colic with the right shoulder-blade pain. Similar manipulation through

the common duct fistulæ produced chiefly the epigastric symptoms. When due to the passage of bodies other than stone the pains, while distressing, are never so agonizing and are much more vague in localization. Colics here as elsewhere are associated with nausea or vomiting or both. The passage of the bodies is followed by sudden instant relief. Protective spasm of the muscles of the belly wall over the area cannot always be differentiated from that produced by duodenal ulcer, renal colic and pylorospasm, but a careful study of the history combined with the necessary analyses will usually make the diagnosis clear prior to operation.

Jaundice incident to the obstructions produced by the passage of bodies along the ducts makes itself evident soon *after* the inception of pain (24 to 48 hours), while painless jaundice is associated with a gradually appearing obstruction such as the thickening of the mucosa at the ampulla, neoplastic narrowing of the lumen either by direct invasion or mechanical pressure at some point along the common duct. The writer early emphasized the fact that the immense barrel-shaped stones in the cystic duct, by mechanical pressure against the common duct, often induce jaundice. In such cases the diagnosis prior to operation has often been emphatically that of "common duct stone," operative interference revealing large cystic duct stone only. Permanent cure of both colic and jaundice is secured by its removal.

Infection of Gall-bladder and Ducts.—Of greater surgical interest and more practical importance than the preceding are the infective processes to which the gall-bladder and ducts are subject, since it is for them that the majority of operative interferences are undertaken.

Bile tract infections, as stated in connection with hepatic abscesses, occur either (1) through the blood stream, or (2) by an ascending infection of the common duct. The vast majority of infections belong in the former class. Of the two blood streams entering the liver, the portal, from the very nature of things, is the one most liable to contain infective elements. Coming as it does from a tract laden with infective organisms, various in kind, uncountable in number, small wonder is it that some are borne along with the products of intestinal digestion to the liver. In health, their number not being too excessive, nor their virulence too great, the liver cells eliminate them by way of the bile tracts; in disease the organisms may accumulate in such numbers or be of such virulence as to produce an inflammation of the lining membrane of these tracts with consequences with which we are all familiar. The nutrient artery bears infective ele-

ments only when there is a general systemic circulatory infection, as in pyæmia, miliary tuberculosis, pneumonia, grippe, etc.

To these the epoch-making researches of Rosenow compel the addition, in the case of acute gangrenous cholecystitis, of a specific streptococcus. Floating to the terminal twigs of the cystic artery, for which it shows the most surprising predilection, it there produces a septic thrombosis with all the sequelæ which characterize this type of destructive gall-bladder inflammation. Working with the abundant material of the Mayo Clinic, he secured with startling regularity, not from the gall-bladder contents, but from the muscularis of the diseased gall-bladder wall, a streptococcus. This organism injected in proper dosage into the blood stream of the dog, rabbit, guinea-pig, with similar regularity induced a typical gangrenous cholecystitis *with practically no other lesions* (Proceedings Chicago Surgical Society, November, 1914).

Although rare, ascending infections are seen, their chief examples being acute catarrhal jaundice and typhoid cholecystitis. In these, as in all other ascending common duct infections, a more or less complete *stasis* of the bile stream is an essential. The ascending infection which leads to catarrhal jaundice is due to an obstruction at the ampulla caused by the swollen mucosa incident to acute gastroenteritis. That of typhoid choleangitis and cystitis is due to hepatargia. An analogous condition is frequently seen in the parotid gland when in typhoid the flora of the mouth grows against the sluggish salivary stream up Steno's duct until the substance of the gland itself is invaded. Just as in the dry mouth of the sufferer from typhoid, whose salivary gland has ceased to secrete, so in the common duct of the typhoid liver the flow of bile is so slow as to give the faint color to the typhoid "stool" and to permit the growth of organisms upward as well as the multiplication of the same organisms coming from above.

Attention must be directed to some of the important changes which these infections make (1) in the bile itself, (2) in the bile tracts, (3) in the pancreatic ducts.

The Bile.—On analysis, gall-stones consist of *cholesterin alone*, *bilirubin calcium* alone, or varying proportions of both with cholesterin usually predominating. While bile normally contains minute traces of cholesterin it never in health contains bilirubin-calcium. The *physiological chemist* has demonstrated the source of cholesterin to be degenerative processes affecting cell protoplasm. Columnar epithelium is that most prone to undergo this metamorphosis; hence the presence of cholesterin in various secretions, like those of the bronchi,

the nose, the steatomata of the ear, the bile tracts, and in those neoplasms lined by columnar epithelium.

The *biologist* has demonstrated, experimentally, and the *pathologist* has found by his research at necropsies, that the influences necessary to induce these degenerative changes are due to the protoplasmic poisons produced by somewhat *attenuated* bacterial organisms. When *such* irritants act on the epithelia the latter are found to undergo degenerative changes, with swelling of the cells, formation of myeloid bodies (cholesterin) within the protoplasm, rupture of cell wall, discharge of contents ("Becker Zell" formation), and the subsequent appearance of cholesterin within the débris. Thus in the lower animals, by attenuated cultures of the colon bacillus introduced into the gall-bladder, it has been possible to induce such changes in the epithelial lining as to increase the cholesterin content of the bile, with resulting cholesterin stone formation. *Active, unattenuated* cultures of colon bacillus, or staphylococcus, on the other hand, induce inflammatory changes with pus formation, precipitate bile salts with no stone formation, no cholesterin. Moynihan has called particular attention to the cholesterin stone formation *in situ* in the muciparous crypts of the gall-bladder mucosa often met with in gall-bladder surgery; in such cases he considers cholecystectomy essential to a cure.

Bilirubin, the coloring matter of bile, a sulphur containing albuminoid derivative, is soluble in the soda salts of the bile. It is a product of the liver cells in health, not a degeneration product. Under certain conditions it may be precipitated with a calcium base, making the insoluble body, bilirubin-calcium, which is the other important constituent of the second group of gall-stones.

These conditions, as in the case of cholesterin formation are most often those of bacterial fermentative action, though conceivable as occasionally due to a pathologic condition of the hepatic secretions incident to age, poor metabolism or lessened alkalinity with precipitation of bilirubin-calcium. The *source*, then, of bilirubin being in the *hepatic cells* themselves, the formation of bilirubin-calcium is rendered possible in the very smallest bile ducts. This type of stone is the one most frequently found intrahepatically and in the ducts. The source of the calcium base with which the bilirubin combines, when precipitated by bacteria, is yet a mooted question. Calcium salts exist in the bile normally, but do not normally combine with bilirubin. If, however, bacterial fermentative changes be induced in the bile, with consequent diminished alkalinity, bilirubin-calcium falls. Thus it will be seen that

bacterial influences are the determining factors of stone formation whether they be of *cholesterin* or *bilirubin-calcium*. The former calculi are found chiefly in the gall-bladder and common ducts the latter probably in the intrahepatic ducts and possibly in the gall-bladder.

We have thus far considered the source of the constituents of gall-stones, but have considered only one of the factors essential to stone formation, which, taken alone will never produce stones. There must be the other factor, *stagnation* of the bile-stream, either in the gall-bladder and its muciparous ducts, or in the bile ducts. If this stagnation be intermittent in character the stone will be laminated. It should be distinctly understood that stagnation alone, however induced, will not produce either variety of stone, but to it must be added a mild bacterial infection, an infection too mild to induce inflammatory reaction in the lining of the tracts, but sufficient to cause degenerative changes in the epithelial lining or a lessened alkalinity of the bile through a fermentative change in its constituents, or both. The stagnation may be inflammatory, neoplastic, or in various ways mechanical. It need not be continuous and must not be absolute. Since the flow of bile in the gall-bladder is not as active as in the ducts this is the site of the more frequent stone formation. The writer presented at the Portland meeting of the American Medical Association a specimen of a liver and bile tracts in which it was impossible to make an incision anywhere into the liver substance without exposing on the cut surfaces numerous stones lying in the lumina of the bile tracts in the exact spots in which they had developed, but in which case not a solitary stone was found in the gall-bladder, although over 400 were removed from the common duct.

Strictures.—Strictures of the bile tracts are occasionally met with in two situations; (1) In the cystic duct, and (2) in the lower portion of the common duct near the ampulla. By far the more frequent site is in the cystic duct. Strictures are sequelæ of ulceration from pressure exacted by impacted stones.

Having removed an impacted stone from the cystic duct, inserted the customary drainage tube, and closed the wound, failure of bile drainage during the convalescence may be the first evidence that such an ulcerative process has destroyed the lining of the cystic duct. Even though at the time of operation bile has escaped and it has been possible to pass a probe into the common duct, such a result may ensue. With such a stricture the wound refuses to heal, the glairy mucus secreted by the gall-bladder continues to be discharged

and a cholecystectomy is necessary before a cure can be attained. When, therefore, the conviction exists that the destructive processes within the cystic duct have probably destroyed its mucosa, a primary cholecystectomy should be made, *with this exception*, however: when the condition of the patient is desperate, when gangrene of the gall-bladder is extensive, when pus is present within and without the gall-bladder, then the simplest procedure that will provide drainage, with least dissemination of the infective elements, is to be used. The future must provide a safer opportunity for the correction of the stricture.

Stricture of the common duct is occasionally the sequel of impacted stone, and may be incident either to pressure ulceration of its mucosa from the stone with subsequent contracture, or to cicatricial contraction after drainage of the common duct for other purposes than the removal of stone, *i.e.*, post-operative. In either event it presents one of the most serious difficulties with which the surgeon is confronted. If untreated, the patient rapidly declines from toxic cholemia; if drainage of the proximal end is instituted the jaundice disappears, but the patient is left with a distressing fistula, which slowly lowers his resistance. On two occasions (the first in December, 1908) I succeeded in relieving this condition as follows: after exposing and dividing the duct at the site of stricture I ligated the duodenal end of the duct and inserted into the open hepatic end a small rubber drainage tube the end of which had been twice turned back on itself making a double revere. About 3 or 4 in. of the other end of the tube was passed through a small opening in the duodenum. The small opening was snugly fitted to the tube by a purse-string suture. The stump of the common duct covering the rubber drain was now sutured to the duodenum, thus effecting an end to side anastomosis between duct and gut. A drain was inserted to the site of anastomosis. In both cases union was secured and the rubber tube was passed per rectum in from seven to nine weeks. During the visit of American Society of Clinical Surgery to Heidelberg (1912) Wilms demonstrated an identical procedure which he had just devised.

When the stone can be localized and is found to be so fixed in the duodenal portion of the common duct, that it cannot be milked back into the free portion, it has been found to be possible to remove it by the transduodenal route of McBurney. This method is so much easier, and when successful gives such a brilliant convalescence for the patient, that the surgeon may be tempted to a dangerous reliance on this route. Incision of the duodenum will ever have attendant dangers

that cannot be foreseen. Patients are peculiarly liable to infection with the duodenal flora, among which the gas bacillus figures disastrously. The digestive juices, here met with in their greatest activity, may make a failure of the most skillfully sutured temporary incision and a frequently fatal leakage. It should then be resorted to only after concluding that the more usual route through the common duct incision is inapplicable.

Fistulæ.—Persistent biliary fistulæ, in the earlier years of operative interference were of frequent occurrence. They were largely incident to the two-step operation of Volkman in which the gall-bladder was first attached to the skin or to the peritoneum and posterior sheath of the rectus by a circular suture, and then opened at the same or subsequent sitting. Since the adoption of the double purse-string inversion of the gall-bladder fundus around the drainage tube and the free dropping of the gall-bladder into the abdomen, such fistulæ are rare (see Fig. 119). When in spite of these precautions fistulæ persist, some obstruction will be found to the flow in the common or cystic duct. *Internal* biliary fistulæ, connecting gall-bladder and colon, gall-bladder and duodenum, gall-bladder and stomach are frequently met with when operating for biliary colics, their existence not having been suspected. Two important facts are thus impressed upon the mind of the surgeon: first, that the dangers of an ascending septic choleangeitis are negligible when it seems desirable to purposely make such fistulæ, and second, in dissecting out a gall-bladder from a mass of adhesions, the surgeon should be on his guard against overlooking a pre-existing anastomosis of this type, for the leakage from the hollow viscus will induce much trouble or even fatality. The writer has removed a gall-bladder that presented three distinct openings, two into the duodenum and one into the colon, necessitating three separate closures of intestinal openings.

Hepatoptosis.—When the mobility of the liver becomes sufficiently marked as to produce a definite hepatoptosis, as evidenced by changed physical signs, especially if associated with distressing symptoms, liver fixation has been recommended. No one method has been adopted as a standard procedure. Shortening of the suspensory ligament with incorporation of the same in the cicatrix of the incision after having irritated the peritoneal covering (friction, Tr. Iodine, scarification, etc.) of the upper convex surface of the liver as well as those surfaces with which this comes into contact, will give the best results. Posture (head of bed low) with supporting bandage of the abdomen during the

formation of the adhesions, is very important for the success of the procedure.

Cholecystitis.—*Treatment of infections of the biliary tracts and their sequelæ.* It must not be forgotten that much can be accomplished in the milder types of gall-bladder inflammation by medication. The well-earned reputation of Carlsbad, Vichy, Harrogate and other spas is dependent upon the actual benefits bestowed.

In the discussion of gall-stone formation attention has been called to the factors necessary to their production. Modification then of the fluidity of the bile, its alkalinity, rate of flow and its capacity for inhibiting bacterial growth, may give rise to a symptomatic cure, even though stones be present in the gall-bladder or bile ducts and may have produced colics. The writer has operated upon several patients who have for years by an annual journey to one of the above "cures" been rendered reasonably comfortable for the greater part of the time. When, however, these medicinal remedies have failed, or the severity of the pain, or the degree of infection has become too severe, then surgical interference becomes imperative. Whether this shall consist in a drainage of the gall-bladder, or its removal should be determined only when that viscus has been exposed to view. Cholecystostomy should be the operation of choice when the involvement of the gall-bladder wall is, in the judgment of the operator, not past repair by rest and drainage. The writer is strongly convinced that many a thickened œdematous and desperately inflamed gall-bladder wall will resume a surprisingly normal character after a brief drainage. Likewise that this drainage offers less jeopardy to the patient's life than its entire removal. When, however, the repeated attacks have produced too great destruction to the gall-bladder wall, when gangrene is so extensive as to be a positive menace or when the suspicion of malignancy exists, cholecystectomy should be done. Seen by the surgeon at times in the very late stages of the septic process, a perforated gall-bladder may be found bathed in pus and bile, more or less walled off by adhesions, in a patient profoundly toxic; in such a case drainage after removal of stones is alone indicated with the least possible disturbance of the adhesions. If the patient survive the sepsis, a secondary operation for the removal of the remains of the gall-bladder can be instituted under conditions favorable to life. This, however, is far less frequently required than would be deemed probable at the time of the primary operation.

Technique of Drainage.—Expose the gall-bladder by the route elsewhere described. Incise the fundus of the gall-bladder. Surround the

opening in the gall-bladder with two concentric purse-string sutures of absorbable material. Insert a soft gum drainage tube, the end of which has been turned back on itself as a sort of collar. Tie each of the sutures around the tube, at the same time inverting the edges of the wound in the gall-bladder (see Fig. 120). This anchors the tube to the viscus in a water-tight fashion. Before closing the abdomen, remove

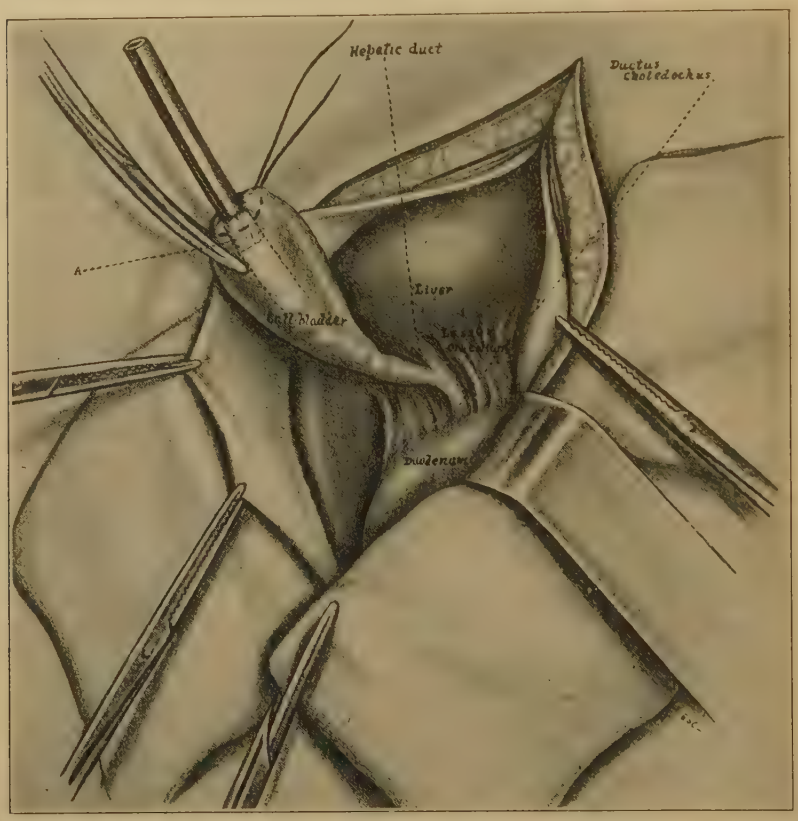

Fig. 119.—Illustrating a double purse-string suture around tube for drainage of gall-bladder, the fundus being inverted and hermetically constricted around the same. When purse-string is tied gall-bladder is dropped back and allowed to assume its future position.

all the external supports used to make liver more accessible. Straighten the flexed table and permit the liver with its drained gall-bladder to resume its normal position. Anchoring of the gall-bladder to the parietes is no longer practised. In those cases in which it has been difficult to secure a hermetic purse-string closure around the drain, it will be found desirable to employ an additional small cigarette or Bullitt drain, to insure the escape externally of any leakage.

Cholecystectomy having been determined upon, the peritoneal covering of the gall-bladder should be incised from the neck to the fundus at such a distance from its liver attachment as shall provide sufficient flaps of the same to cover the surface about to be denuded by the subperitoneal gall-bladder removal. Application of an angular clamp forceps to the cystic duct will both control hemorrhage, fix the pedicle and render the removal of the same safe and rapid. After isolation of the cystic portion of the gall-bladder, separate forceps should be applied in order to prevent escape of contents. Separate ligation of the cystic artery is desirable where feasible. Temporary drainage down to the stump of the cystic duct should be made. Cholecystectomy for primary malignant neoplasm in an early stage is indicated, and follows the technique for such growths.

Drainage of the common duct is practised, as a routine, after the search for and removal of stones producing symptoms. Here too, the continuous free flow of bile through the drain inserted, in a remarkably brief time relieves the patient of septic choleangitis and icterus of even severe grade, so that in the space of a fortnight, the drain may usually be removed and the fistula allowed to heal. The difficulties attending the exploration of the common duct will be reduced to a minimum if the hints given under the heading "Access to the liver" be borne in mind. The pulling up of the free margin of the liver by an assistant, after the more liberal incision described, the putting of the gall-bladder neck on the stretch by traction, the incision and reflection of the peritoneal covering of the junction of the cystic with the common duct, will render the procedure more facile when the absence of palpable stone makes the orientation difficult. The claim of Gerster that the duct should be incised in every case in which operative indications have justified operation, I believe well founded, as many a stone will become evident in the collapsed duct that remains undiscovered in the distended duct. If palpation be attempted prior to the incision, it should always begin at the hilus of the liver and proceed downward toward the duodenum. Small stones have otherwise escaped into one or other hepatic duct and failed of removal, though momentarily felt. Since the predominating symptom in common duct stone is an icterus, drainage is almost invariably indicated, while in carefully selected cases of calculi situated in the gall-bladder alone, we can many times hasten convalescence and relieve our patient of much unpleasant and painful after-treatment by closing the incised gall-bladder at once (ideal cholecystotomy).

In a few cases of single, ball-valve, common duct stone, unaccompanied by septic phenomena, the common duct may likewise be closed, a temporary cigarette drain being inserted down to the line of suture in the duct. In such cases the writer, after incising the duct over

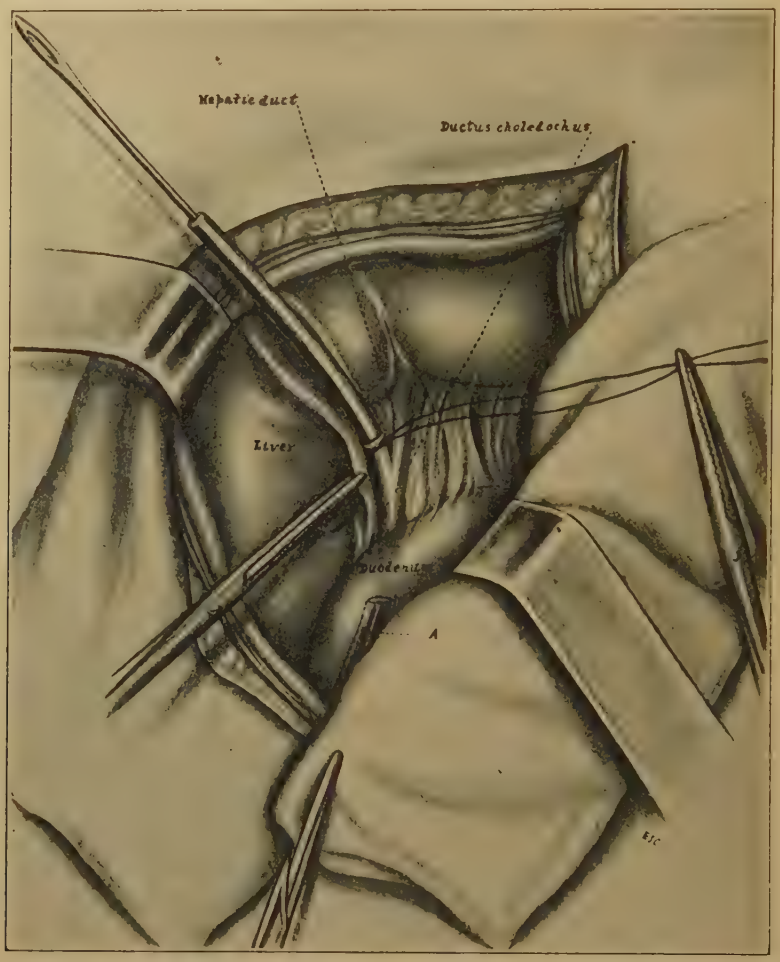

FIG. 120.—Illustrating the introduction of a drain toward, or into, the duodenum after the removal of gall-bladder or incision of common duct for stone. Matas prefers carrying the free end of the catheter 3 or 4 in. into the duodenum through which salt solution, nutrient solution or medicaments can be introduced instantly in any desired amount into the intestines. A probe is illustrated as passing through the catheter and determining the presence of catheter free in the lumen of the duodenum.

the stone held in position between two fingers, has found it helpful to insert the stitches in the duct edges *before* removing the calculus. If the stone be of the single round, non-facetted variety, and the bile

appears normal, the sutures are tied, after making the usual exploration for other stones and determining that the ampulla is patent. If the stones are multiple or friable, the bile abnormal, or the jaundice marked, a drain is inserted and the sutures tied. While thus making the closure of the duct fairly hermetic, the free ends of the sutures are used to anchor the drain by tying two or three of them around the tube. The recommendation of the writer that the direction of the drain be *toward* instead of *from* the duodenum, and that its caliber be less than will occlude the common duct, has been followed often enough by many of our recognized teachers to convince them that the advantages claimed for the change make it the better practice (Fig. 120). Those advantages briefly stated here have been written of elsewhere by Matas, the Mayos, Clairemont, Von Haberer and others, and depend upon this now well-settled fact that *solutions* of any appropriate kind in any desired quantity can be introduced into the duodenum and thus into the system of the patient. Therefore, either through the tube introduced into the gall-bladder or through a ureteral catheter passed through the drain thus placed in the common duct we can (1) fill the blood-vessels, (2) flush out the kidneys, (3) wash out the stomach if vomiting is bothersome, and free the tissues of their bile pigment most promptly. A cholemic nephritis is so common an accompaniment of a chronic common duct stone occlusion that the addition of an anæsthetic is often sufficient to provoke a complete anuria. The writer has saved, as have Matas and others, cases that seemed otherwise hopeless by the free instillation into the duodenum of 1, 2 and even 3 liters of hypotonic salt solution. Indeed, Matas has gone farther and made in a normal gall-bladder a quick cholecystostomy for the treatment of an acute septic nephritis with anuria which had resisted the usual recognized procedures, and saved the patient, the urinary output immediately increasing under the liberal instillation of warm Vichy Celestin.

SECTION X

SURGERY OF THE PANCREAS

By

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Experimental.—The anatomical defect of the human pancreas from a surgical standpoint seems to be that it is largely retroperitoneal and, therefore, lacks peritoneal repair material. The most serious problem in pancreatic surgery has been fat necrosis. Our experiments on dogs confirm those of Opie and others, that fat necrosis occurs only when pancreatic fluid is poured into or confined in the retroperitoneal fat, including the mesenteries and omenta. On the other hand, if the pancreatic duct is severed and the end so arranged that all the fluid is poured into the peritoneal cavity, there follows no fat necrosis, provided a sufficient quantity of protected gauze drainage is placed to readily conduct the pancreatic fluid to the surface. The severed or split pancreatic duct may be treated just as the common bile duct is treated under similar circumstances, except that the stripped pancreatic duct is not adapted to direct implantation into the intestine, as indicated by our experiments on six dogs, in which direct implantation of the stripped pancreatic duct was done after Desjardin's technique. In every instance the duct sloughed and in only one case was there even a fistula connecting the duct with the intestine 25 days after operation. The other five cases had died of fat necrosis and peritonitis, resulting from complete obliteration of the implanted duct. Moreover, in more than 20 dogs in which we implanted the end of the pancreas into a loop of intestine, the duct was allowed to protrude from the cut end of the pancreas at the time of operation. When the dogs were killed and the specimens removed, the protruding duct had disappeared down to the pancreatic tissue.

It seems probable that the pancreatic duct does not carry sufficient blood supply to maintain its own nutrition. On the other hand, we are able to make a perfect implantation of the cut end of the pancreas itself into the intestine and still maintain the integrity of the duct. The implantation is done as follows:

Pick up a loop of jejunum and clamp both limbs with a rubber-covered stomach clamp, leaving a loop 3 or 4 in. beyond the clamp. Beginning at the apex of the loop, unite the afferent and efferent segments near their mesenteric edge by a continuous Lembert suture, to a point near the clamp (Fig. 121). Grasp the thread with a forceps at this point, and hold until all other steps of the operation are completed, just as is done in performing gastroenterostomy (Fig. 122, *C*.1).

Second.—With a knife or scissors open the intestine around the loop as indicated by dotted line (Fig. 121), thus cutting the two segments of intestines into one (Fig. 122).

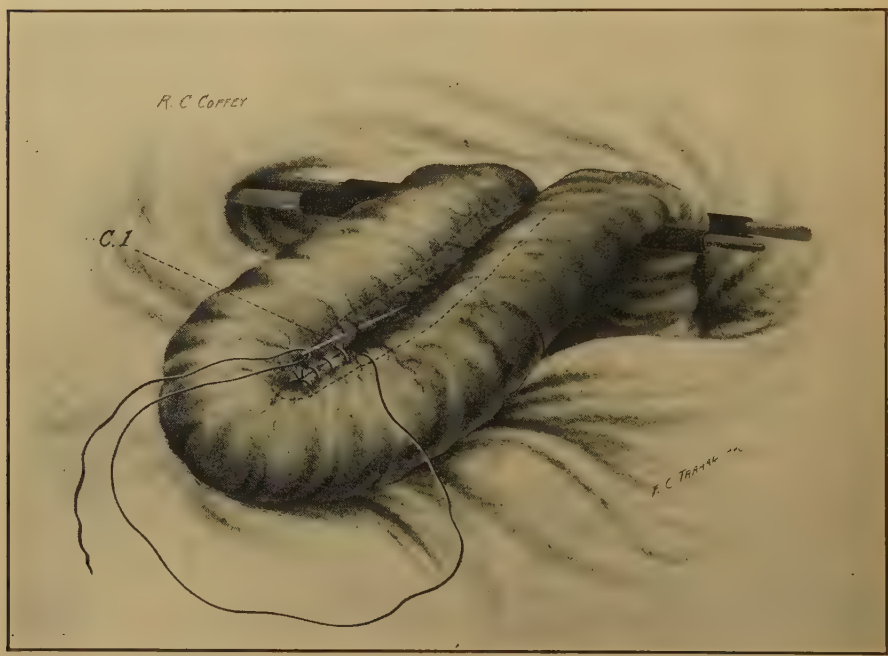

Fig. 121.—Suturing arms of intestinal loop together with primary continuous Lembert suture, *C*.1 (dotted line indicates where incision is to be made).

Third.—Begin a through-and-through continuous catgut suture on the inside of the intestine, and continue around in the same manner as the deep suturing of gastroenterostomy. Stop the through-and-through suture when the end resembles the cut end of a single intestine, and tie a knot (Fig. 123, *C*.2).

Fourth.—Strip off enough pancreatic tissue to expose the end of the duct, and ligate the vein and artery which frequently accompany it. Pass two quilt sutures of catgut, through the pancreas near the end, for

traction sutures. The ends of one pass from before backward, and the ends of the other from behind forward. These traction sutures are threaded on needles at both ends, and passed from the peritoneal side into the lumen of the intestine, near the cut edge, including about one-quarter of the circumference of the intestine between the two threads. These sutures are then passed into the lumen of the intestine 1 in. or more, and brought out $\frac{1}{4}$ in. apart. Traction on these sutures at once inverts the edge of the intestine and draws the pancreas into the peritoneal canal (Fig. 123). A row of fine silk or linen sutures is now placed

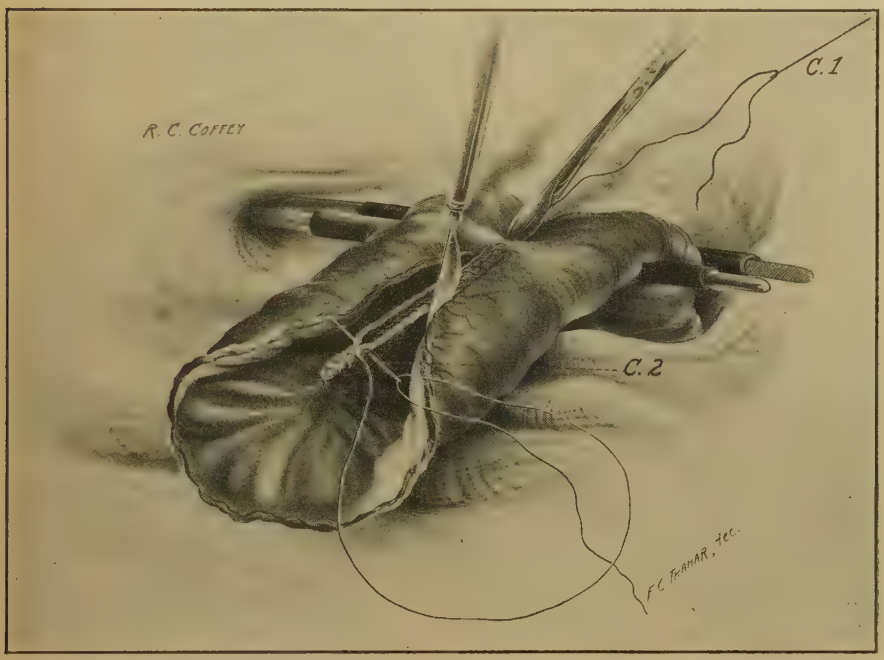

FIG. 122.—Opening intestinal loop and beginning the through-and-through suture, *C*.2. (*C*.1, primary continuous Lembert suture.)

around the entire pancreas (Fig. 124, *I*.1). The traction sutures are then pulled upon and the pancreas still further drawn in, and the loop still further inverted, when another row of interrupted sutures is placed (Fig. 125, *I*.2). Finally the traction loops are tied on the outside of the intestine, and the peritoneum of the intestine is drawn further upon the pancreas so as to cover in the pancreatic sutures by what we call collar sutures (Fig. 125, *C.S.*). Finish the operation by continuing the primary peritoneal suture around to the pancreas (Fig. 125, *C*.1).

Experimentally, if the tail of the pancreas is cut off and the cut end

with open duct is implanted into a loop of intestine, it heals over and the duct also is closed by a transparent film, the pancreatic fluid all flowing through the normal channels to the duodenum. Second, if the tail of the pancreas is planted in the same way, and the ducts of Santorini and Wirsung are ligated with linen, the pancreatic fluid is delivered backward into the intestinal loop for a few days, but by the end of 10 days the pancreatic delivery ducts are re-established around the ligatures, and the panceratic juice is found flowing altogether

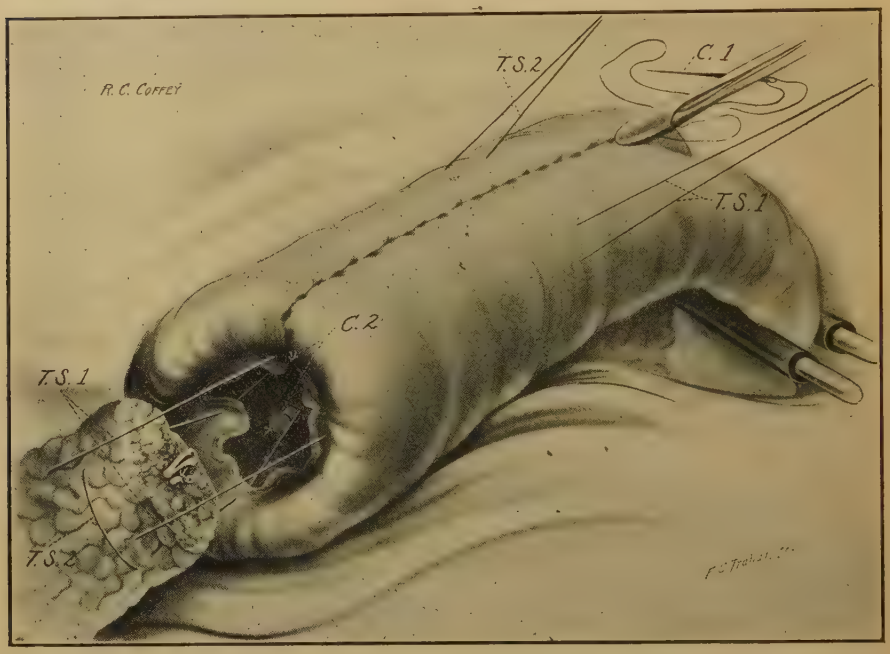

Fig. 123.—Introducing cut end of pancreas and inverting double intestine with traction sutures. *T S* 1 and *T.S.*2, traction sutures. *C.*2, beginning and end of through-and-through-suture. (*C.*1, primary continuous Lembert suture.)

through its normal openings. Third, if the implantation is accompanied by severing the delivery duct between ligatures, and separation of the ends by interposing omentum, the implanted duct remains open and delivers the pancreatic fluid backward through the implanted tail into the intestine (Fig. 126).

We are able to successfully remove the head of the pancreas and implant the cut end into the intestine, with good results in cases in which dogs survive the shock of the operation. If both ducts are ligated and no provision is made for the temporary delivery of the pancreatic fluid, an acute pancreatitis with fat necrosis is established

in some cases, particularly if the operation is done during active digestion. If the duct of Wirsung alone is ligated, and the dog is not actively digesting at the time of the operation, very little disturbance is noticed, inasmuch as the duct of Santorini seems to take up the delivery of the fluid, but in a few days the duct of Wirsung is re-established around the ligature and everything is normal

Later work indicates that we may sever the pancreas, or crush it in its continuity, and that its ducts are restored, provided the

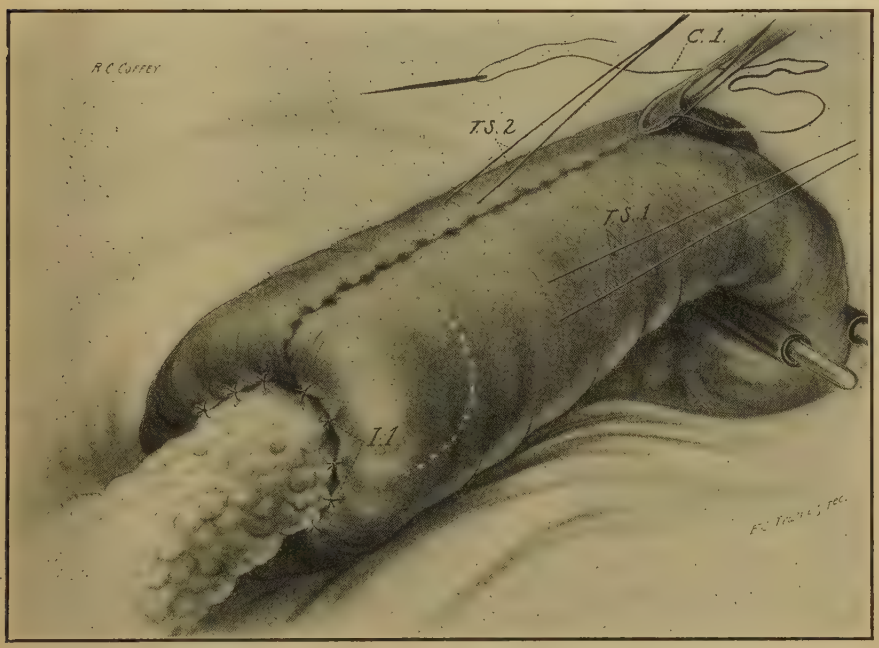

FIG. 124.—End of pancreas drawn in, intestinal tube partially inverted and first layer of interrupted sutures placed. *I.*1, interrupted sutures, *T.S.*1 and *T.S.*2, traction sutures. *C.*1, primary continuous Lembert suture. (White dotted line indicates position of end of pancreas in intestine.)

wounded surfaces are approximated and ample drainage is used to temporarily deliver the pancreatic juice to the surface. Therefore, we approach the threshold of clinical surgery of the pancreas with the following principles, indicated by experimental work:

First.—Peritoneum must be brought to the field of operation in all direct pancreatic surgery.

Second.—Fat necrosis occurs only when the pancreatic fluid is delivered directly into the extraperitoneal fat.

Third.—Pancreatic fluid is but little more dangerous than bile to

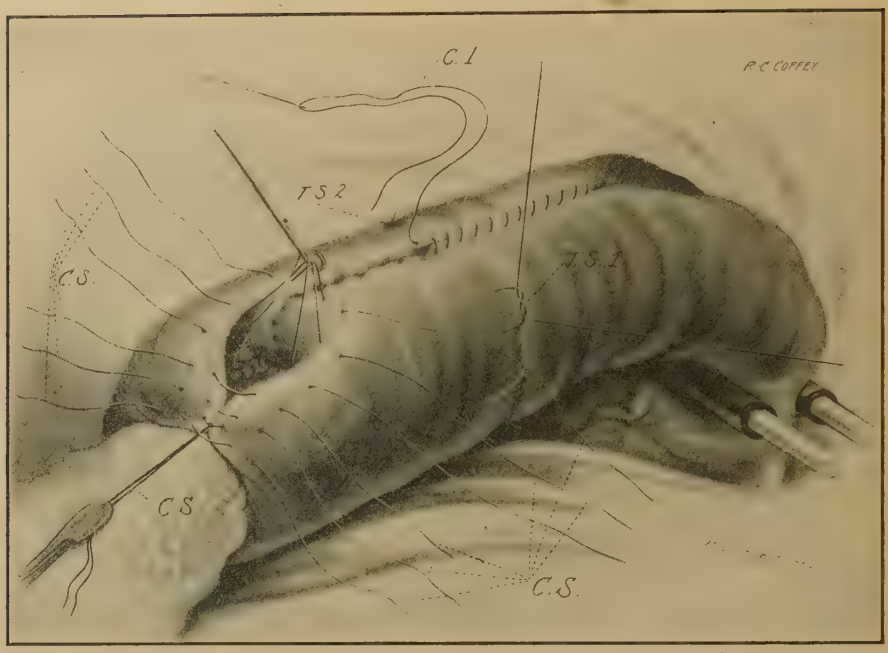

FIG. 125.—Completing operation by placing collar sutures and finishing with primary continuous Lembert suture. *C.S.*, collar sutures. *I.2*, interrupted sutures 2. *C.1*, primary continuous Lembert suture.

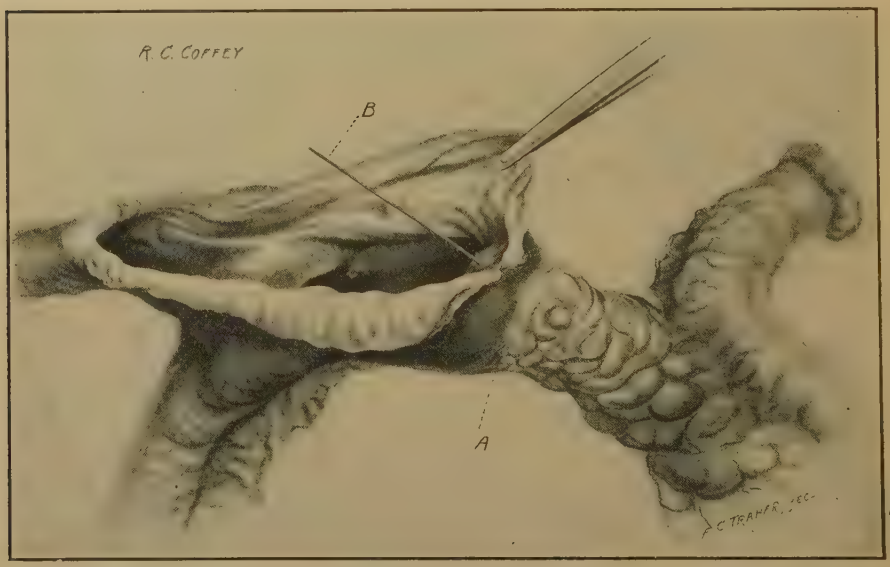

FIG. 126.—Drawing from fresh specimen removed from dog five weeks after operation, showing result of pancreato-enterostomy. *A*, line of union between pancreas and intestine. *B*, probe in open end of pancreatic duct. *C*, intestinal lumen through the loop.

the peritoneum, provided ample drainage is used to deliver it to the surface at once.

Fourth.—The pancreatic duct seems to depend upon contiguous pancreatic blood supply for its nutrition, and therefore is not adapted to direct implantation into the intestine.

Fifth.—The cut end of the pancreas, carrying an open duct, may be implanted into a loop of intestine, with the same assurance that an intestinal anastomosis is made.

Sixth.—There is a marked tendency of the pancreatic ducts to re-establish continuity around a gap or an obstacle, provided the pancreatic fluid is temporarily delivered to the surface.

Seventh.—If the head of the pancreas is removed and the open end is brought to the surface, a pancreatic fistula results, which usually closes in a few weeks. The secreting portion of the gland is rapidly destroyed, leaving a fibrous cord which contains many Islands of Langerhans. Such a dog lives indefinitely in fairly good health, but for a time has fatty stools.

The Anatomy and Physiology of the Pancreas.—The primitive pancreas springs from the intestinal canal by two buds. The dorsal pancreas is at first a stomach-like enlargement of the digestive tube. The ventral pancreas springs from the junction of the hepatic diverticulum and the intestine. According to Mall, the two pancreases have merged in an embryo of 22.8 mm. The ventral pancreas forms a part of the head, more or less of the uncinate process, and retains the duct of Wirsung. The dorsal pancreas forms the remainder of the head, together with the entire body and tail, and retains the duct of Santorini, the two ducts having anastomosed in early fœtal development. The pancreas is classed as a compound racemose gland, analogous in structure to the salivary glands. It varies in color from cream to a decided pink, depending on the stage of digestion. As an average we may state, roughly, that the pancreas is 6 in. long, 1½ in. wide and ¾ in. thick. It has been divided for convenience into head, which is prolonged into the uncinate process and fills the concavity of the duodenum; the neck, which is about 1 in. long; and the body and tail, which extend into the hilus of the spleen. It lies transversely, crossing the spine in front of the first or second lumbar vetebra. From right to left the posterior surface of the head of the pancreas is in relation with the inferior vena cava, the right renal vessels, and the right pillars of the diaphragm. Behind the neck is the portal vein. Behind the body and tail are the aorta, superior mesenteric artery,

left pillar of diaphragm, splenic vein, left kidney and its vessels, and the left suprarenal capsule.

In the quadruped the pancreas lies between the layers of the mesentery of the duodenum, and is surrounded by peritoneum. In man the duodenum and pancreas have rotated to the right and become fixed to the posterior parietal peritoneum, causing absorption and obliteration of the adjacent layers; consequently the pancreas of the human is retroperitoneal. The transverse mesocolon, which is in early development fused with the posterior layers of the omentum, comes off from the pancreas along its anterior border, at which point the two layers of the mesocolon separate. The anterior layer, which comes from the lesser peritoneum and omentum, covers part of the anterior and superior surface, and the posterior layer covers the anterior and inferior surface. The two layers over the head of the pancreas separate, leaving a considerable surface without attached peritoneal covering.

The pancreas is made up of a number of lobules, each of which consists of one of the ultimate ramifications of the pancreatic duct, which ramification terminates in a number of cæcal pouches or alveoli, which are tubular and somewhat convoluted. In the connective tissue between the alveoli and gland tubules are found collections of cells called Islands of Langerhans. The alveoli are filled with secreting cells and are continuous with the tubules forming the ducts. These minute ducts come together in the tail of the pancreas like the springs at the source of a river, and form the source of the pancreatic duct, which passes to the right, receiving other ducts in its course, gradually increasing in size until it reaches the neck of the pancreas. Here the main duct is transferred from the primitive dorsal to the ventral pancreas and thus becomes the duct of Wirsung. Here it drops downward to receive part of the secretion from the head and uncinate process, and tends backward to unite with the common bile duct in the ampulla of Vater, which is in the wall of the duodenum, just under the mucous membrane. The joint duct then traverses the space between the mucosa and muscle from ¼ to ¾ in., making a flap of mucous membrane similar to that seen protecting the ureter in the bladder (Fig. 127, 4). This flap serves as an effectual valve to prevent ascending infection from the duodenum. The duct of Santorini enters the duodenum nearly an inch above the opening of the common bile duct (Fig. 127, 6), and is the duct of the primitive dorsal pancreas (Fig. 127, 2). It connects with the main duct in the neck. Mayo

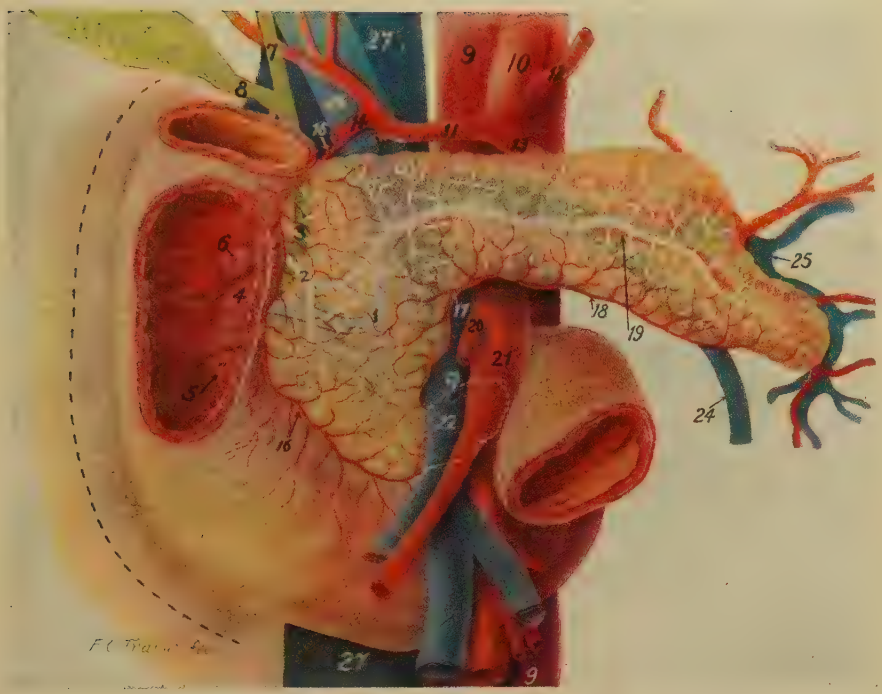

FIG. 127.—Anatomy and relations of the pancreas. 1. Duct of Wirsung. 2, Duct of Santorini. 3. Common bile duct. 4. Ampulla of Vater. 5. Caruncula major. 6. Caruncula minor. 7. Hepatic duct. 8. Cystic duct. 9. Abdominal aorta. 10. Cœliac axis. 11. Hepatic artery. 12. Gastric artery. 13. Splenic artery. 14. Gastroduodenalis artery. 15. Pyloric artery. 16. Pancreato-duodenalis superior artery. 17. Pancreato-duodenalis inferior artery. 18. Inferior pancreatic artery. 19, Pancreatico magna artery. 20. Middle colic artery. 21. Superior mesenteric artery. 22. Superior mesenteric vein. 23. Middle colic vein. 24. Inferior mesenteric vein. 25. Splenic vein. 26. Portal vein. 27. Vena cava.

Black dotted line indicates site for mobilizing duodenum. White dotted line including 22 represents position of uncinate process running behind mesenteric vessels.

Robson states that the duct of Santorini is always present, though sometimes not active.

The pancreas is well supplied with blood as shown in Fig. 127. The nerves enter from the celiac, mesenteric and splenic plexuses. The lymphatics form a network about the lobules and pass by vessels to the surface of the pancreas, and enter into lymphatic glands upon the pancreas. The splenic glands receive most of the trunks. Deaver has recently made a valuable contribution on this subject.

From the physiological standpoint the pancreas may be said to be the universal gland of the body, inasmuch as it may furnish working substitutes for practically all the digestive juices, as well as perform the duties of a ductless gland. Its ferment amylopsin may take the place of the salivary glands, thus admitting of their removal. The ferment trypsin may take the place of the stomach juices, thus admitting of its removal. The ferment steapsin may substitute for bile, in the emulsion of fats, thus permitting more or less permanent drainage of bile to the surface, and also produces a milk-curdling element which takes another function of the stomach. It produces an internal secretion in the Islands of Langerhans, which is essential in the chain of the ductless glands. Per contra, it is found that while digestive secretions of the pancreas are very important, they are by no means essential and may be substituted by the salivary glands, the stomach and liver. This has been proven repeatedly by experimentally delivering the pancreatic juices to the surface, without seriously impairing the health of the animal or patient, as the case may be. On the other hand, the removal of the complete pancreas, with the Islands of Langerhans, produces death by breaking the co-ordinating chain of ductless glands (which include the hypophysis, thyroid gland, Islands of Langerhans in the pancreas, suprarenal body, and to a certain extent the sexual glands, all of which seem to have an important relation to metabolism).

Acute Hemorrhagic Pancreatitis.—Acute hemorrhagic pancreatitis is a very violent disease, coming on suddenly, usually without fever and with great shock. Fitz classified acute pancreatitis as hemorrhagic, gangrenous and suppurative. Our recent knowledge of the disease indicates that these classes are simply stages in the same disease, the first stage of which is the hemorrhagic pancreatitis, and which shows a swollen, deeply congested and at times almost black appearance. Hemorrhagic spots occur in the pancreas, the circulation of certain areas is shut off, the pancreatic ducts themselves are destroyed and the pancreatic ferments are freed in the fat spaces, producing fat necrosis.

At this stage it is usually found that there is no bacterial invasion. The pressure of the hemorrhage and the action of the digestive ferments so destroy the circulation of the pancreas as to cause gangrene of portions of it. This constitutes the second or gangrenous stage. The gangrenous portions gradually become infected, producing the suppurative or third stage.

Etiology.—The large percentage of cases occur in middle-aged, otherwise healthy men who are inclined to corpulency. Of Korte's 44 cases, 30 were males and 14 females. The youngest patient was 16 years, the oldest 70, but the majority were from 40 to 60 years of age. Of the 44 cases, 22 had cholelithiasis. Opie states that if a stone is lodged in the ampulla of Vatter, and blocks both the common bile duct and pancreatic duct, a chronic pancreatitis takes place; but if the stone is small and blocks the ampulla below the entrance of the pancreatic duct, bile is forced into the pancreas, producing acute hemorrhagic pancreatitis. This was based largely upon experimental introduction of bile into the pancreatic ducts. Others believe that in many cases hemorrhage is secondary to some general condition, which causes a disease of the blood-vessels. Others believe that disease of the pancreatic ducts, which allows the escape of pancreatic fluid into its substance destroys the coats of blood-vessels and produces a hemorrhage. Some believe that infection may ascend the ducts from the intestine producing it.

Symptoms.—The majority of Korte's patients complained, in giving their history, of having similar attacks of milder degree on previous occasions, and usually referred to them as cramps of the stomach that had been usually diagnosed as gall-stone colic. Fourteen of the 44 cases gave no prodromata. A few spoke of having attacks of acute indigestion and others seemed to point to alcoholism as a cause. Usually his patients could state the particular days on which the attack came on. The most constant symptoms in his cases were severe epigastric pain, belching, vomiting, great shock and collapse, pain usually above the umbilicus, abdomen rigid as in perforation. The peritoneum and intestinal canal being involved present symptoms both of intestinal obstruction and peritonitis, but usually without fever.

Diagnosis.—The diagnosis is very difficult. The Cammidge reaction is of no value and the sugar test is of but small value, as it occurs only in late stages.

Of Korte's 44 cases, 34 were operated on. Of the 34, 18 were diagnosed before operations, 13 after the abdomen was opened, by spots of fat necrosis, and in three cases he failed to recognize the con-

dition with the abdomen open. He made the diagnosis several days after the operation, however, by discovering pieces of the gland coming through the drainage wound.

Prognosis.—Korte in 1894 advised against operations in the acute stage of pancreatitis. In his paper of 1910 in the "Annals of Surgery," he has reversed his opinion and now advises early operation. The statistics which had been reported in literature since 1905 included 103 cases, with 41 recoveries and 62 deaths, or 60 per cent. mortality. Of his own statistics including 44 cases, 38 were operated on. Of these, 34 were operated on by direct attack of the pancreas, with 16 deaths and 18 recoveries. The other four were treated by draining the bile passages. Korte's paper was so eminently thorough and scientific, and so in accord with other leading operators who have reported cases, that we may well let his percentage represent the present-day mortality of acute pancreatitis when well treated.

As to the best time to operate, Korte gives the following results of his own work: Of 12 operated on during the first week, eight recovered and four died; of four during the second week, three recovered and one died; of seven during the third week, four recovered and three died; of seven during the fourth week, three recovered and four died; and of four during the fifth week, none recovered and four died.

Treatment.—As to the method of operation in these acute cases, the pancreas may be attacked through the gastrohepatic omentum, gastrocolic omentum, or below the transverse mesocolon. The attack through the gastrocolic omentum seems more reasonable in most cases. Korte recommends opening through the gastrocolic omentum and incising the swollen pancreas, or boring into it with the finger, followed by the insertion of a large amount of drainage (Fig. 128). The writer has followed this technique in three instances, with two recoveries and one death. At times the surgeon is not consulted until the suppurative stage is reached, in which the symptoms may be particularly noticeable in one or the other kidney regions. Suppuration has taken place and the pus is burrowing toward the left flank or the right flank, as the case may be. In a few instances it is best to open such an accumulation from the back, but I am personally of the opinion that such indication is rare and that it is much safer to open through the gastrocolic omentum, and pack the lesser peritoneal cavity with a large amount of gauze laid in straight wicks (Fig. 128). If a very large portion of the pancreas has sloughed away in the acute process, it is often found that diabetes develops months or even years afterward.

It seems that surgery in the hands of an able surgeon offers some improvement over conservative treatment, but the outlook is not brilliant. With the best treatment and knowledge available, approximately 50 per cent. will prove fatal, by any means of treatment we now have.

Subacute Pancreatitis.—Subacute pancreatitis is the name applied to localized suppurative accumulations in the pancreas. They are usually due to late bacterial invasion of the necrotic spots, following

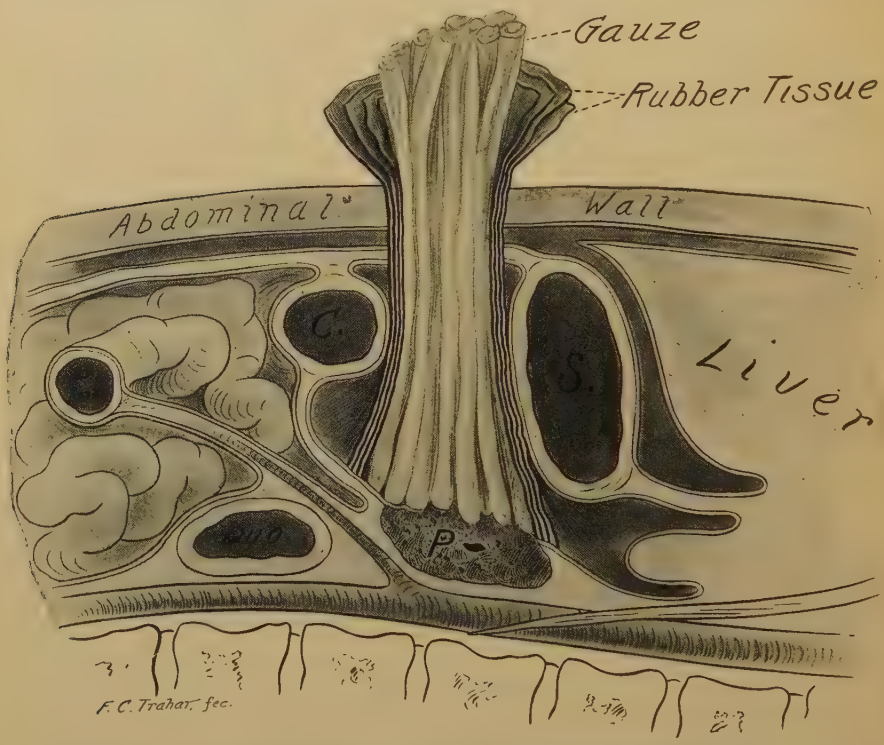

FIG. 128.—Protective gauze pack for pancreatic drainage, applicable in acute pancreatitis resulting from pancreatic injuries; pancreatic cysts; pancreatic abscess, and for wrapping end of pancreas and delivering fluid to surface after removal of head of pancreas.

primary hemorrhagic pancreatitis. A few abscesses have been found in the pancreas, which seem to have originated from the blood stream, or from an ascending infection in the ducts, or through lymph channels, or in some cases the abscess extends from a neighboring organ. Diagnosis is often difficult or impossible, the symptoms being very much the same as acute hemorrhagic pancreatitis, plus the fever, and in most cases is a sequel of the hemorrhagic type. The treatment is

entirely surgical and consists of opening the abscess through the gastrocolic or gastrohepatic omentum and lesser peritoneal cavity, and draining with a large pack of gauze wicks laid straight (Fig. 128).

Chronic Pancreatitis.—Chronic pancreatitis is usually, if not always, a secondary disease. It results either from obstruction of the duct by stone or growth, from direct extension of infection from the gall tract, or from lymphatic extension of infection from a diseased or infected area of some other organ (usually the duodenum, appendix or large intestine). Its treatment, therefore, must be directed entirely to the antecedent pathology. It is now quite generally conceded that a well-established chronic pancreatitis is not a surgical disease itself. A very significant fact is that Mayo Robson, who was one of the earliest and most ardent advocates of the surgical treatment of chronic pancreatitis, does not mention it in his chapter on Surgery of the Pancreas, in Burghard's Surgery, published in 1909. Deaver, in an article in the Journal of the American Medical Assn., January, 1913, says: "Chronic pancreatitis, when it has progressed to the stage of interlobular and interacinar fibrous deposit, is not more curable than is cirrhosis of the liver or chronic nephritis."

Pancreatic Cysts.—Most authors have divided pancreatic cysts into true and false. A false cyst is described as a localized collection of fluid in the lesser peritoneal cavity, or in the neighborhood of the pancreas, and is usually of traumatic origin.

We may divide true pancreatic cysts into retention and proliferative.

Retention cysts may result from a gradual obstruction of some one of the larger pancreatic ducts, or from traumatism. Gradual obstruction is produced, first by pancreatic stones which develop in the ducts and grow gradually; second, by localized interstitial pancreatitis, which causes gradual encroachment on the ducts.

A traumatic retention cyst is formed by extravasated blood which has been acted upon by pancreatic juice coming from obstructed or severed ducts. The walls of retention cysts of the pancreas are very thick, according to Opie, contain pancreatic tissue and are lined by a single layer of cylindrical cells.

Under the head of proliferative cysts, we may bring the various forms of malignant cysts, also cyst adenomata, resembling those of the ovary. Hydatid cysts are occasionally seen.

Concerning the origin of cysts, Korte, reporting on 117 cases of pancreatic cysts, found that 28 per cent. were of traumatic origin. The relative frequency of proliferative cysts has been variously estimated

by different authors at from 10 to 20 per cent. of pancreatic cysts. This would leave about 80 per cent. to be classed as retention cysts, about 35 per cent. of which are traumatic.

Symptoms of pancreatic cysts as given by Opie are as follows: A rounded tumor, fluctuating on palpation and situated in the epigastric region behind the stomach and the greater part to the left of the median line suggests the presence of a pancreatic cyst. Korte has found the tumor in the median line in 48 cases. In 40 cases he found the greater part of the tumor to the left of the median line and in 10 to the right. Cysts situated in the tail of the pancreas may extend below the umbilicus, even into the pelvis, or may show in the left loin. The cyst most frequently grows forward between the stomach and colon, but may be above the stomach or below the colon. According to Opie pain is the earliest and most prominent symptom, is deep seated and is usually located in the epigastrium. It is even greater while the tumor is yet too small to be palpable. Indigestion and constipation from pressure are sometimes noticed along with a proportionate loss of weight. Functional disturbances are only occasionally marked with pancreatic cysts. Pancreatic cysts may be confused with cysts of the liver, kidneys, mesentery or with an aortic aneurism.

Treatment.—Surgery offers the only relief for pancreatic cysts. In a small proportion of proliferative cysts enucleation may be practised, but as a rule all forms of pancreatic cysts are best treated by drainage. If the cyst is large, its wall is sutured to the parietal peritoneum and the fluid removed by aspiration, after which the cavity is packed with gauze wicks (Fig. 128). If it is small, it is exposed by going through the gastro-colic omentum and extensive packs or sponges are placed around it for protection. Its contents are removed by aspiration, followed by incision, after which the cavity is packed with extensive gauze wick drains, laid straight. The protective gauze sponges are now removed, additional gauze wicks are laid around the outside of the cyst-wall, and all the wicks are then surrounded by gutta-percha tissue (Fig. 128). This form of treatment is usually successful, but occasionally a pancreatic fistula persists for months or even years. In every case of pancreatic cyst, careful search should be made for the cause of the obstruction whether it is pancreatic stones or pancreatitis.

Pancreatic Calculi.—Pancreatic calculi are comparatively rare. According to Robson, Osser in 1903 could find record of only 70 cases. Since that time, however, others have been reported. Robson made the

important discovery that pancreatic stones cast a shadow to the X-ray. This is of special importance, inasmuch as a considerable proportion of retention cysts, as well as cases of steatorrhœa without cysts and a certain proportion of cases of diabetes, are found to be due to blocking by stones. By means of the X-ray the stones should be diagnosed and located and the location of the primary incision determined in this way. Lazerus, according to Opie, found glycosuria in 40 per cent. of pancreatic calculi cases, while on the other hand, pancreatic calculi were found in slightly less than 2 per cent. of cases of diabetes. Fitz found pancreatic stones in 7 out of 29 cases of steatorrhœa. Loss of weight is often a marked symptom.

Treatment.—Surgery affords the only rational treatment. While Robson as late as 1909 was able to find only five deliberate operations for the removal of pancreatic calculi, the operation should now be much more frequent, since we know we can lay open the pancreas and its ducts and remove stones with but little danger, provided drainage is properly applied (Fig. 128). Link, of Indianapolis, mobilized the tail of the pancreas and laid open the duct for several inches, removed a number of stones, sewed a tube into the center of the pancreas, brought the tail containing the tube out through the abdominal wound and left it for drainage (Annals of Surgery, June, 1911). The fistula healed and the patient made a good recovery.

Traumatism of the Pancreas.—Traumatism of the pancreas is more frequent than is generally diagnosed. Injuries have been classed by Robson as penetrating and subcutaneous. The penetrating are usually gunshot or stab wounds. Mikulicz, in the Annals of Surgery, July, 1903, reported 45 cases of pancreatic injuries, 21 penetrating and 24 subcutaneous. Of the 21 penetrating wounds, 12 were gunshot wounds and 9 stab wounds. Five of the 12 gunshot wounds were operated on and 3 recovered. Seven were not operated on and all died. In 7 of the 9 stab wounds, the pancreas was partly prolapsed. All were operated on and recovered. The two that were not prolapsed did not recover. Of 24 subcutaneous injuries the 13 not operated on all died, but of the 11 operated on, 7 recovered. The principles for treatment of pancreatic injuries are very simple, and include a thorough exposure of the pancreas, cleansing and coapting the surfaces or ends with sutures. By thus bringing the ducts close together, the tendency of their re-establishment is very marked. After the ends are brought together, a large protected gauze drain tempo-

rarily delivers the pancreatic fluid to the surface (Fig. 128) and thereby prevents extensive fat necrosis.

The literature has been replete with illustrative cases, showing the necessity for exploration of all doubtful cases of subcutaneous ab-

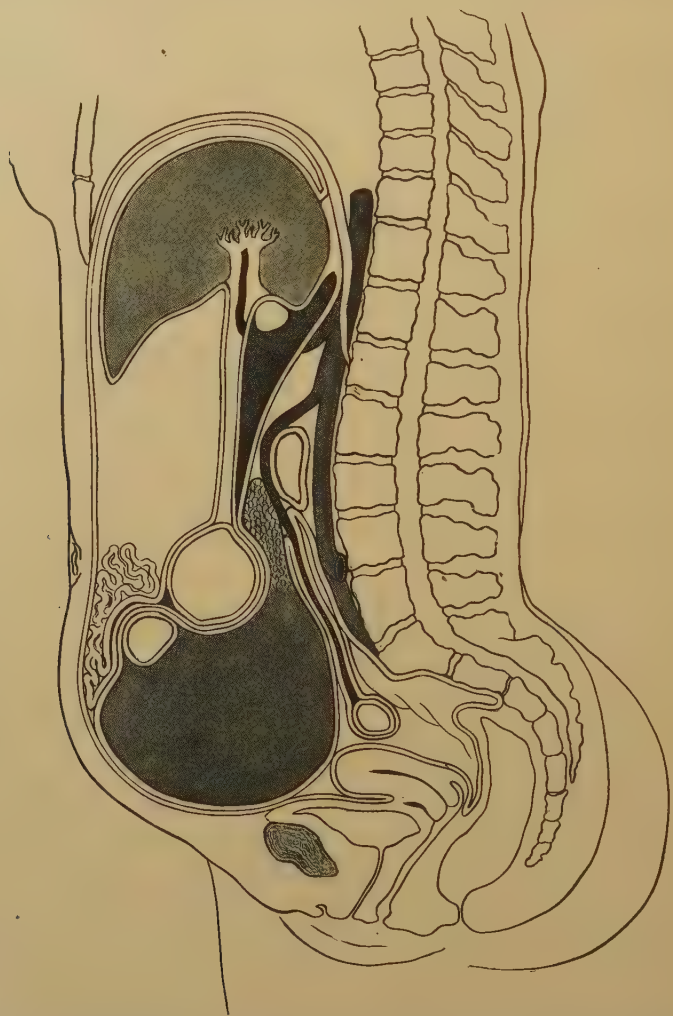

FIG. 129.—A 7-lb. pancreatic tumor presenting below the colon, mistaken for a pelvic tumor. Patient remained well one and one half years after operation, when growth returned and death resulted six months later.

dominal injury. For this reason a much larger percentage of the cases will be saved in the future, by prompt surgical measures.

Tumors of the Pancreas.—But few non-malignant solid tumors of the pancreas have been reported. Finney resected the middle of the

pancreas for cyst adenoma, the size of a lemon and sutured the two ends together. Drainage was used and a perfect recovery followed. Holden, of Portland, reported to the Portland City and County Medical Society the removal of a non-malignant tumor from the tail of the pancreas, the size of an orange with good results. I removed a tumor springing from the tail of the pancreas, which weighed 7 lb. and which was operated on with the diagnosis of a pelvic tumor (Fig. 129). The tumor was pronounced adenoma by an amateur pathologist. It recurred, however, in 18 months, and the patient died six months later of cancer involving all the upper abdomen.

Malignant tumors of the pancreas are far more frequent. Segrè reporting on 11,472 autopsies on cancer patients, found that 1.1 per cent. of all cancers are primary in the pancreas. Bashford in 84,448 autopsies, found 1.18 per cent. Bashford reporting on 50,660 autopsies in females dying of cancer, found 0.93 per cent. were primary in the pancreas. In 33,788 on males dying with cancer 1.55 per cent. were primary in the pancreas. Thus one cancer in every 107 women, and one in every 65 in men, is found to be primary in the pancreas. As to location, 60 per cent. have been found in the head, 2 per cent. in the tail, 5 per cent. in the body, and the remaining 33 per cent. the entire pancreas was so involved as to make it impossible to determine the origin. Secondary carcinoma of the pancreas extending from the stomach and gall tracts, is by no means rare. Sarcoma of the pancreas is only about one-sixtieth as frequent as carcinoma. Carcinoma of the pancreas is usually too far advanced before a diagnosis is made, to admit of surgical treatment. Occasionally, however, a carcinoma of the head of the pancreas is discovered early enough to admit of its successful removal, notwithstanding the fact that results so far obtained are by no means encouraging. It seems quite likely, however, that the future will bring better results.

Bloodgood in September, 1911, removed the head of the pancreas and duodenum and brought the cut end of the pancreas out through the abdominal wound to establish a fistula. The patient made a good recovery, the fistula closed, but the patient died of recurrence in the liver, something less than a year after the operation. Post-mortem showed that the pancreas had contracted to a fibrous cord and that the Islands of Langerhans had apparently been preserved and therefore the patient had not given any symptoms attributable to the absence of the pancreas. This bears out animal experiments reported before in this article. Similar cases have been reported from

time to time. The anatomical difficulties, as shown in Fig. 127, have deterred most men from attempting pancreatectomy, inasmuch as it involves a number of major operations in one.

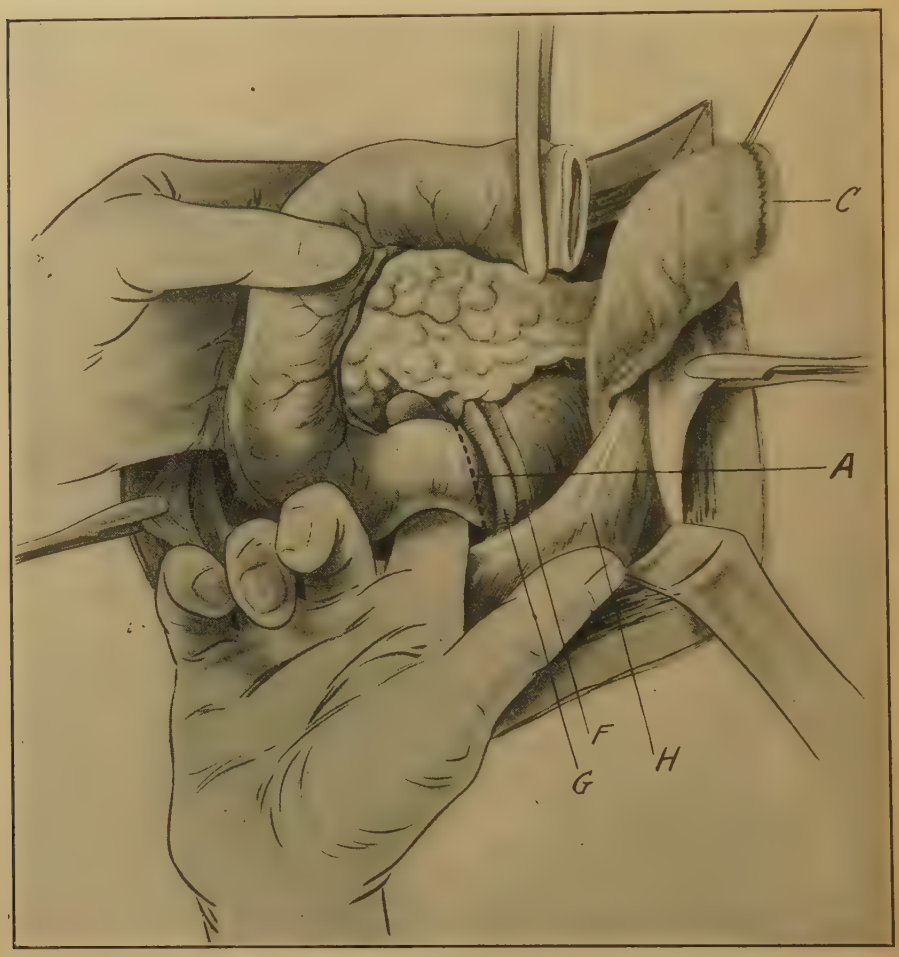

FIG. 130.—Separation of the duodenum to the point of section, indicated by the dotted line *A*. The mesenteric vessels cross it just beyond. *C*, pyloric end of stomach. *F*, superior mesenteric artery. *G*, superior mesenteric vein. *H*, mesocolon. (*Sauve.*)

Sauve, in an article, has given us a good anatomical description of the operation for removal of the head of the pancreas and duodenum, in the following words:

"*Technique of Pancreatectomy.*—To succeed in removing the head of the pancreas, an operator must avoid three things: injury to the portal vein; injury to the superior mesenteric vessels, which is followed

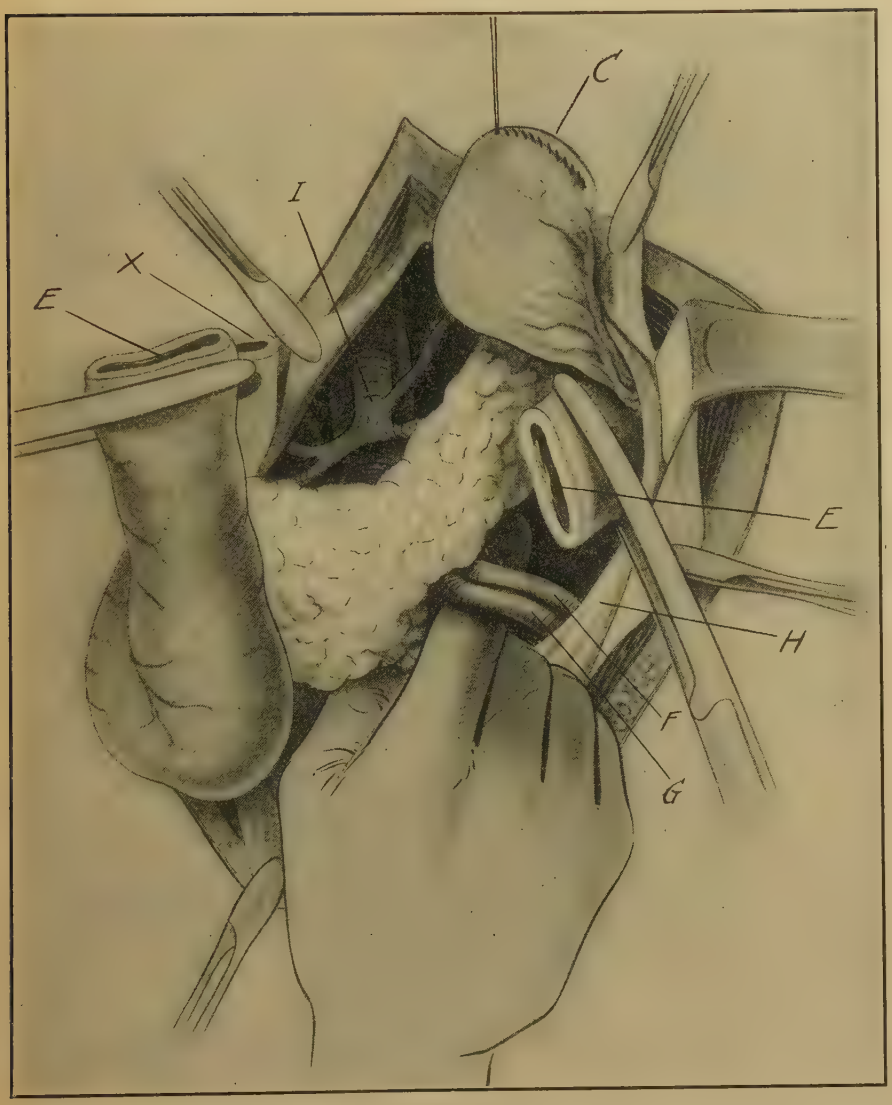

FIG. 131.—The index finger carefully separates the mesenteric vessels from the lesser lobe of the pancreas. *C*, pyloric end of stomach. *E*, lower cut ends of duodenum. *X*, upper cut end of duodenum. *G*, superior mesenteric vein. *F*, superior mesenteric artery. *H*, mesocolon. (*Sauve.*)

by gangrene of the small intestine; injury to the right colic artery, which is followed by gangrene of a part of the colon. The following technique is advised:

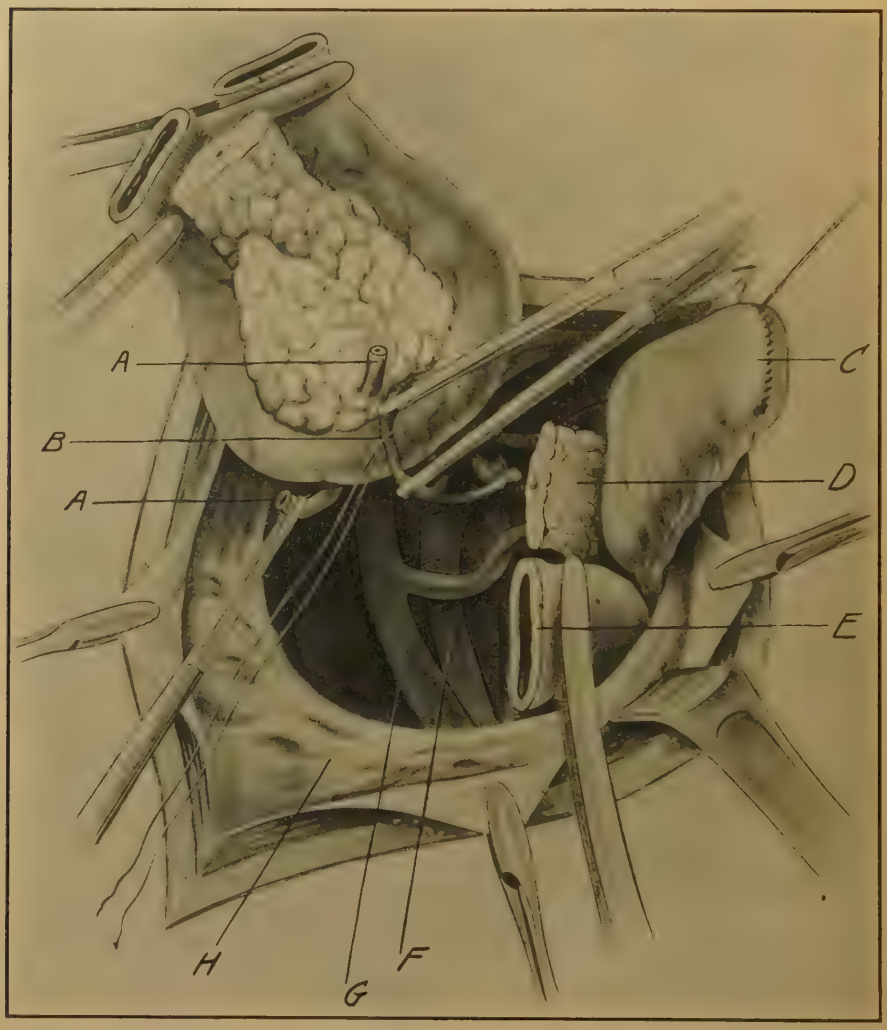

FIG. 132.—Appearance after removal of head of pancreas and duodenum. *A.A.*, divided common bile duct. *B*, gastroduodenal artery. *C*, pyloric end of stomach. *D*, tail of pancreas. *E*, lower cut end of duodenum. *F*, superior mesenteric artery. *G*, superior mesenteric vein. *H*, mesocolon. (*Sauve.*)

"1. A median incision from the ensiform to below the umbilicus. A bayonet incision gives a much better exposure than a linear incision of equal length.

"2. Ligature of the pyloric artery, of the gastroduodenal artery, section of the pylorus and suture of the gastric wound.

"3. Division of the fascia along the right border of the duodenum; posterior dissection of the second portion of the duodenum and the head of the pancreas (dotted line Fig. 127).

"4. Section of the duodenum at a point sufficiently far from the superior mesenteric vessels to protect them from injury (Fig. 130). The dissection of the duodenum should be carried to a point at which it can be easily separated from the head of the pancreas, but not to the

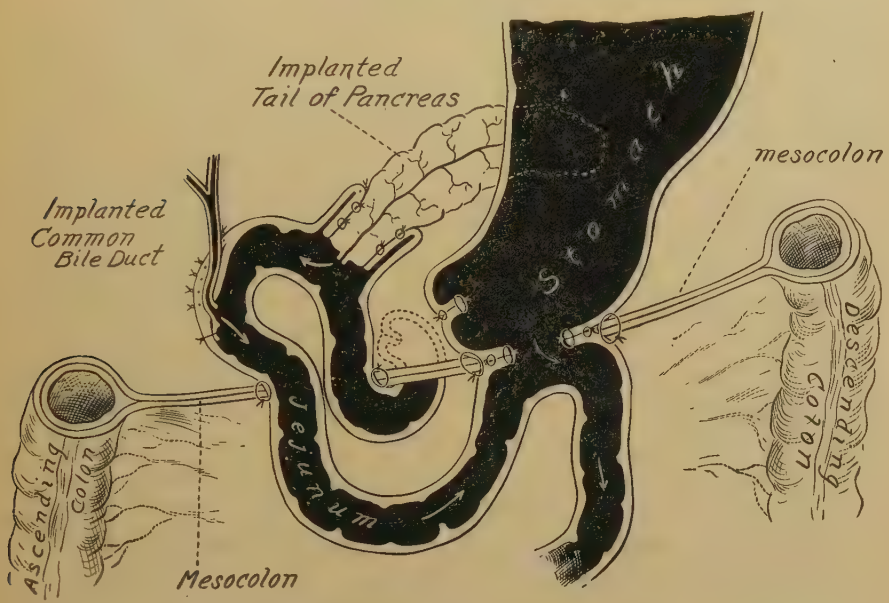

FIG. 133.—Scheme for re-establishing functions of stomach, pancreas and gall ducts after removal of duodenum and head of pancreas.

mesenteric vessels. Ligation below the pancreaticoduodenal vessels. Section of the duodenum and suture of its lower end (Fig. 131).

"5. Separation of the lesser pancreas from the mesenteric vessels which cross in front of this portion. Separation of the pancreas from the portal vein.

"6. Section of the head of the pancreas (Fig. 132). It is desirable to leave enough of the tail to bring the cut surface into the abdominal wound. The common duct remains to be ligated and divided, the gastroduodenal artery is ligated a second time for surety and divided and the portions of the duodenum and pancreas are thus removed

(Fig. 132). The exposed vessels are inspected to make sure they are uninjured.

"There remain three necessary steps: (*a*) re-establishment of the alimentary canal; (*b*) re-establishment of the biliary canal; (*c*) disposition of the tail of the pancreas."

I have worked out an operation on the cadaver, based on the principles established in our experimental surgery, which has for its purpose the restoration of all the functions, and is performed as follows: (Fig. 133).

After the head of the pancreas and the duodenum have been removed by Suave's method, a posterior gastroenterostomy is made between the stomach and jejunum, about 3 ft. below the ligament of Treitz, the perforation of the mesocolon being as far to the left as possible. Through another perforation of the mesocolon, further to the right, the loop of jejunum above the anastomosis is drawn into the upper compartment of the abdomen, through the mesocolon where the stump of the pancreas and the severed bile duct may be implanted into it, by methods previously described. By this method the ends of the pancreatic and bile ducts would not be exposed to infection by the passing current of intestinal contents and would neutralize the acid of the stomach contents and thus prevent injury to the intestinal mucous membrane by acidity. If the carcinoma can be discovered before jaundice is evident, it will probably be better to do the gastroenterostomy and turn in the ends of the stomach, as a preliminary operation, and remove the head of the pancreas and duodenum and implant the pancreas and bile duct at the second operation. Inasmuch as many of these patients are jaundiced before the diagnosis is made, it is probable that in most cases it will be necessary to do all the operation at one time, which will necessarily carry a considerable mortality from shock (Freman).

In secondary contact involvement, encountered in cancer of the stomach, a considerable portion of the head of the pancreas may be shaved off and the stump of the duodenum sutured in the gap as described by W. J. Mayo. I have in such cases supplanted this by suturing omentum to the field and placing a drain below, which is brought out through a stab wound to the right of the incision.

SECTION XI

SURGERY OF THE SPLEEN, ADRENALS AND RETROPERITONEAL SPACE

By

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The spleen which is the largest of the ductless glands lies in the left hypochondrium and has the shape of a tetrahedron with its long axis lying in the same direction as the tenth rib. The peritoneum almost completely invests the gland and two portions of this membrane, the gastrosplenic and the lienorenal ligaments, attach the hilum of the spleen to the fundus of the stomach internally and the anterior aspect of the left kidney inferiorly. The phrenic aspect is larger than the colonic or renal and adapts its shape to the concavity of the diaphragm by which it is separated from the ninth, tenth and eleventh ribs. The deepest pocket of the pleural cavity and the thin marginal portions of the left lung intervene between the outer aspect of the spleen and the parietes. It comes into close contact with the left kidney, the stomach and splenic flexure of the colon which contribute to its support. On the concave gastric surface is the hilum, which transmits the vessels and nerves. Immediately posterior to the hilum rests the tail of the pancreas. The spleen is about 5 in. long and 3 in. wide. It therefore has to be considerably increased in size to be palpable. It has a dark blue or purplish color, due to the pigment of degenerated red cells arrested within its tissue. It weighs about 150 gm. The splenic artery is very large, being a branch of the cœliac axis and permits all the blood in the body to pass through the spleen in a short time. The nerves are from the solar plexus and the splanchnic sympathetics ramify in its capsule. There are no filaments from the spinal cord as the spleen is one of the primitive organs of the body and existed possibly before the development of the central nervous system.

The absence of the spleen is compatible with health, for the gland is not essential to life. After removal the bone marrow and lymph nodes take on its function. It is an organ of internal secretion controlled by hormones acting through its blood stream.

Its mysterious function, having to do with the production of the white blood cells in embryo, apparently ceases at birth after which it renovates the erythrocytes. When diseased, it reverts to its primitive function as characterized by an enormous proliferation of the white cells and a wholesale destruction of the red corpuscles with great increase in its own size.

Diseases of the Spleen which may Demand Surgical Intervention.—1. Primary splenomegaly, splenic anæmia and Banti's disease. 2. Pernicious anemia. 3. New growths. 4. Cysts, true and false, the latter usually following hemorrhage into its substance. 5. Wandering spleen when painful, adherent or with twisted pedicle. 8. Malarial hypertrophy, if unaffected by specific treatment or when ruptured. 7. Abscess, usually of embolic origin. 8. Tuberculosis, if primary and causing tumor. 9. Injuries.

In pernicious anemia, massive quantities of whole blood should be transfused 24 or 48 hours before splenectomy and after a hemolytic test has been made. This may be repeated until the patient is brought into a safely operable condition.

The chief contraindication to operations on the spleen is leukemia. A blood examination is always imperative in making the diagnosis. No case of removal of the spleen for leukemia has ever outlived the disease which has uniformly continued to a fatal termination. The other non-surgical enlargements of the spleen are associated with (1) pernicious anæmia; (2) splenomegalic polycythemia; (3) typhoid fever and (4) kala-azar.

"Differential Diagnosis of Splenic Tumors."—Splenic tumors may be almost of any size, even filling the greater part of the abdomen. In most cases, however, the enlargement is greatest in the left side and the spleen, unless fixed by adhesions, moves with respiration. The enlarged spleen is so closely applied to the abdominal wall that it is impossible to insinuate the hand between its upper margin and the costal border; it has a sharp inner border which is almost always interrupted by one, two or three notches. Splenic tumors always grow forward, they never produce fullness in the loin. The dullness in percussion extends up to the sixth rib or higher in the mid-axillary line. The colon is first displaced downward and later lies behind the enlarged spleen, so that any resonance due to it will be in the flank or loin. In many cases of splenic enlargement the blood examination aids in making a diagnosis" (Ashhurst).

Splenectomy.—The operation for removal of the spleen may be extremely easy when there is a completed mesentery allowing the spleen to wander, or the operation may be so very difficult from perisplenitis, with inseparable adhesions, as to compel its abandonment.

The usual incision is to the outer side of the left rectus muscle from the costal margin downward until ample exposure is effected. The Bevan incision in the outer half of the left rectus muscle with the inner angular prolongation across the rectus, kept about an inch from the costal arch and used as a catch for a catspaw retractor is recommended by Mayo.

If diagnosis is uncertain a median incision is preferable and, if necessary, the left rectus muscle can be subsequently divided transversely (Payr).

A transverse incision parallel to the costal border is sufficient when the splenic tumor is small.

When the abdomen is open, the hand can be passed under the diaphragm and any frail adhesions may be gently separated. Great care should be employed as the capsule is very thin and the spleen extremely friable. If adhesions are firm or dense, they should be separated cautiously between ligatures, as hemorrhage from this source is the greatest danger and, coming from the dome of the diaphragm, may be very difficult to control. The spleen should be turned over if possible, and delivered through the incision to render the vessels more easily accessible. It is a good plan to hold it in a gauze sponge to facilitate its control. A large hot gauze pack should be inserted in the space from which the spleen is dislocated. The cardiac end of the stomach and splenic flexure of the colon are brought out on the surface with the gland. The gastrosplenic omentum is thus made taut and its anterior leaflet divided between two or three forceps or ligatures. The left gastroepiploic vessels and the vasa brevia lie on the posterior layer of the gastrosplenic omentum. They are easily seen, pushed aside and avoided. The posterior layer can then be divided between clamps and tied.

John Gerster has suggested preliminary ligation of splenic artery at cœliac axis or superior border of pancreas.

The lienorenal ligament being put on the stretch can be identified below and its anterior layer grasped and divided between forceps at a point in front of the blood-vessels. The splenic artery and vein are thereby exposed. This vascular pedicle is secured by a rubber-covered stomach clamp or a lower kidney forceps (Fig. 134), similarly pro-

tected, 3 in. from the spleen, if possible. Care should be taken not to include the tail of the pancreas. This, however, has been done accidentally and unavoidably without serious injury. The clamp controls the hemorrhage temporarily until ligation can be completed. The pedicle is firmly tied close to the spleen in three or four sections with strong catgut. The tumor is then removed (Fig. 135). The clamp should be loosened gradually so that any hemorrhage seen can be controlled by additional ligatures. The margin of the pedicle can be whipped over by a running suture. Any deep bleeding should be

Fig. 134.—(*Mayo.*)

controlled with the snaking catgut suture in a small needle and with a gauze pack, if necessary (Fig. 136).

If any accessory spleens are seen in the pedicle they should be preserved, unless the operation is for malignancy.

The mortality of splenectomy has been computed at from 18.5 to 27.5 per cent. Mayo says it should not be above 10 per cent.; however, and in 58 operations at his hands there were only 5 deaths.

Splenopexy.—When a vagrant spleen, otherwise normal, is en-

countered it can be fixed in position by one of the following plans.

Rydygier's Method.

An incision is made in the left linea semilunaris. If necessary a

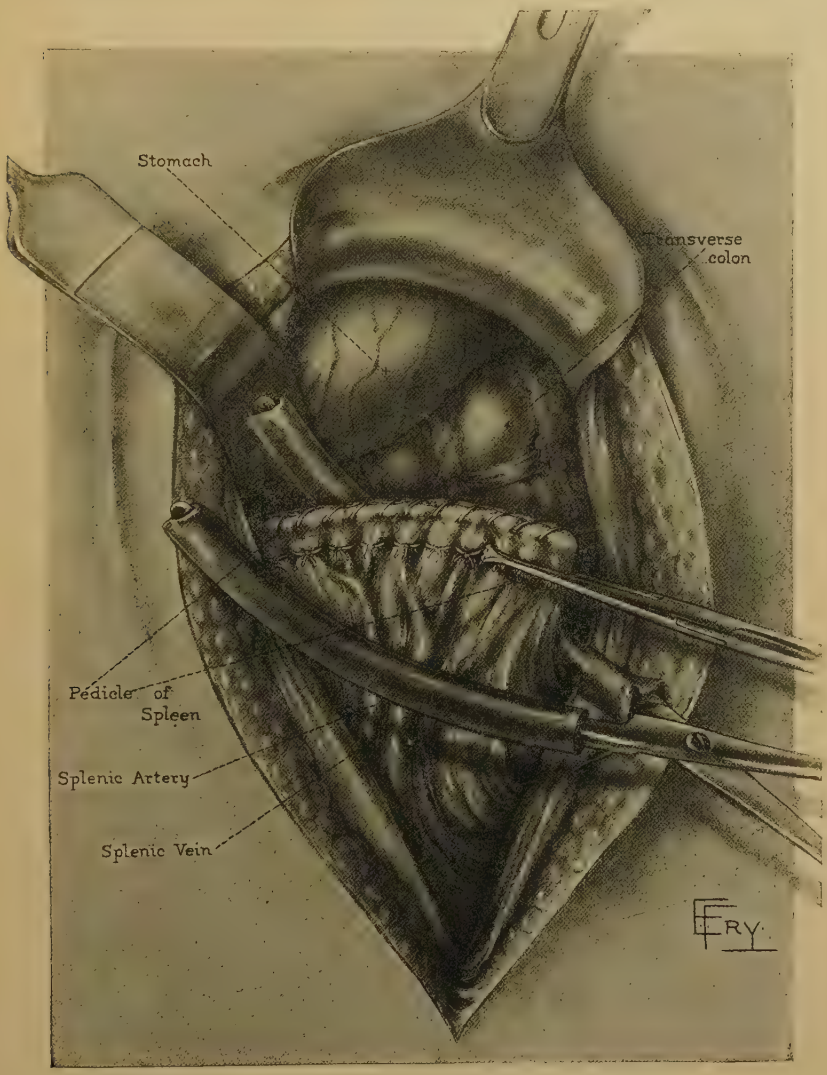

FIG. 135.—Pedicle tied in sections. (*Mayo Clinic.*)

transverse incision at right angles can be added. The principle is to make a pocket in the peritoneum of the lateral parietes in which the spleen may be marsupialized.

An incision is made through the peritoneum on a level with the

normal habitat of the spleen between the ninth and tenth ribs. The peritoneum is separated from the lateral wall by the fingers until a pouch is made large enough to receive the lower half of the gland. The upper flap can be raised similarily. When the spleen is deposited subperitoneally the margins of the peritoneum should be fixed to the

FIG. 136.—(*Mayo, Annals of Surgery*).

gastrosplenic omentum by interrupted catgut sutures. Considerable difficulty is experienced in separating the peritoneum from the under surface of the diaphragm. If so, the peritoneal envelope below can be made sufficiently large to accommodate the entire spleen by bisecting

the peritoneal covering of the pouch and then closing it over after the spleen has been deposited.

If the pedicle is short it can be controlled by having two forceps on it, the groove made by the proximal forceps holding the ligature while the pedicle is steadied by the distal forceps.

Bardenhauer's Method.

With the patient on the right side an incision is made from the last rib to the crest of the ilium and, when the peritoneum is reached, it should be pushed off the parietal wall for a space large enough to accommodate the spleen between the abdominal wall and the detached peritoneum. The opening in the peritoneum should be sufficient to permit delivery of the spleen, which when found, is drawn through the peritoneal aperture. The margins of the incision should then be closed over the pedicle of the spleen and the abdominal wall over the gland in its transplanted position. The wandering spleen can also be anchored in its position by surrounding it with gauze which is led out of the partly closed incision. The gauze is allowed to remain six or seven days, or until aseptic adhesions are formed which are designated to hold the spleen in position.

ADRENALS

The Adrenals.—The adrenal capsules are two small ductless glands belonging to the chromaffin system situated under the diaphragm in close relationship to the spine and opposite the eleventh and twelfth ribs. The right suprarenal is crossed by the superior vena cava and lies in contact with the liver behind the foramen of Winslow. It rests upon the "anterior and inner aspect of the upper end of the right kidney" (Cunningham).

The left adrenal gland is behind the stomach and covered by the peritoneum of the lesser peritoneal cavity. The pancreas and vessels supplying the spleen cover the lower surface.

The posterior aspect in its upper portion lies against the left crus of the diaphragm while below it rests on the inner border of the left kidney from which it is separated by a considerable quantity of fat. The aorta, inferior phrenic and renal arteries each send a branch to supply the gland.

The secretion, adrenalin, suprarenin, or epinephrin, is the natural stimulynt to the blood-vessels, heart and muscular system. It apparently has an important share in body growth, especially in the development of the genitals.

Tuberculosis is estimated by McCosh to comprise 80 per cent. of the pathological changes in the adrenals. When it (Addison's disease) is unilateral the tuberculous gland should be removed.

The most common neoplasms of the adrenal bodies are cysts. A number of these have been successfully removed. Adenomata and other benign neoplasms as well as primary sarcoma and carcinoma are very rare, but have been encountered.

Adrenalectomy.—This operation is most infrequent and extraordinarily difficult. The incision is made obliquely below and following the course of the last rib downward and inward toward the umbilicus. This gives a fairly satisfactory exposure. Cystic tumors are apt to be adherent to the kidney, colon and other neighboring organs. If the kidney cannot be freed or pushed down it may be removed, as most of the growths necessitating adrenalectomy involve the kidney also. The adhesions are very numerous and difficult to separate, and in some cases the mass is peeled off the vertebræ and aorta. If the pedicle cannot be secured by ligature an artery forcep may be left on for 48 hours. The dangers of the operation are shock, hemorrhage, injury to the sympathetic plexus or adjacent hollow viscera.

RETROPERITONEAL SPACE

Retroperitoneal Space.—The retroperitoneal space is a comparative large area of loosely constructed connective tissue. While it is bountifully supplied with lymphatics, they are seldom involved surgically.

Tuberculous lymphadenoma is the most frequent condition. It is usually mesenteric and occurs in young life. When lymphomas are very large, operation may be indicated, if hygienic and X-ray treatment have failed. Connected segments of the intestine may have to be removed. Enucleation of a single or a few nodes can be effected without resection. Hemorrhage is controlled and the peritoneum sutured without drainage.

Abscess of the retroperitoneal lymph-glands may require evacuation and drainage. The glands lying near the ileocæcal valve are most frequently attacked.

Lymphadenitis from the various intra-abdominal sources of infection as well as from the extremities may cause retroperitoneal abscess. It is best approached by an extraperitoneal incision made just above and parallel with Poupart's ligament. When it points in the loin, the lumbar incision is made.

Carcinoma more frequently involves the subpyloric and retropyloric glands, or glands of the greater and lesser curvature, as metastases from cancer of the stomach.

Cancer of the uterus usually invades the lumbar nodes.

Cancer of the testicle involves the ileolumbar glands during the early stages of the disease. Adjacent retroperitoneal glands demand removal, with the primary focus, when possible.

Lymphosarcoma is the most frequent primary retroperitoneal neoplasm.

Lipoma is found most frequently under the mesentery of the large or small intestine. Enucleation endangers the blood supply of this segment of the bowel and should be carefully safeguarded. Keep behind the prerenal fascia, which separates the tumor from the important blood-vessels. When accessibly situated and not too large, if the tumor is firmly grasped in both hands of an assistant and its coverings put on the stretch, simple division of the capsule will, by pressure aided with dry gauze dissection, allow the tumor to be expressed from its capsule with surprising ease.

SECTION XII

KIDNEY AND URETER

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DEVELOPMENT OF THE KIDNEY AND URETER

The urogenital system passes through many developmental changes before reaching the stage found in the adult. This is especially true of the excretory portion of the system, and the importance of a clear understanding of the various stages of development through which the kidneys and ureters pass, is apparent, when it is considered that much of their surgical pathology is based upon abnormal or anomalous conditions which persist from embryonic life.

The kidney is an excretory gland which supplants three other structures of similar function that are present during the development of the embryo. These structures are (1) the pronephros, or rudimentary kidney; (2) the mesonephros, or primitive kidney; and (3) the metanephros, or definitive kidney. The various changes in both morphology and location which the metanephros undergoes during intra-uterine life are the final stages of the development of the kidney.

Pronephros.—The earliest excretory organ of the urogenital system is the pronephros. In man this at no time can be considered more than a vestigial structure, and it is found only in very early embryonic stages. It consists of a few short tubules, with fairly well developed vascular glomeruli at their funnel-shaped ends, at the cephalic end of that portion of the mesoblastic tissue which is known as the wolffian body or nephrogenic cord (Felix, W., in Keibel and Mall, Human Embryology, 1912, II, 752). In lower animals the pronephros has a true excretory function during embryonic existence and in bony fishes (teleosts) the pronephric tubules are present in adult life (Landois, Human Physiology, 1905).

The pronephric tubules lie in a transverse position and connect with a common excretory duct which extends longitudinally in the direction of the cloaca. The tubules of the pronephros soon degenerate and dis-

appear, but the duct remains and becomes the excretory duct of the metanephros. This duct is commonly known as the wolffian or mesonephric duct. It develops in a caudal direction until finally it gains an opening into the urogenital subdivision of the cloaca.

Mesonephros.—The mesonephros develops caudad to the pronephros in the mesoblastic tissue above referred to as the wolffian body or nephrogenic cord. In embryos of 15 to 20 days a number of transverse cell cords form in this region, lying parallel to each other like the teeth of a comb. A lumen appears in each of these cell cords and they connect at one end with the mesonephric duct, while near the other end of each of these tubules a vascular glomerulus forms with branches from the aorta. These glomeruli become invaginated in the free ends of the tubules and the latter become coiled. Tubules and glomeruli thus form the primitive excretory organ, the mesonephros. A segmental arrangement of the mesonephric cell cords is the primary condition with usually a single pair of tubules, one on each side, for each segment behind the pronephros, as far caudad as the pelvic region. The number of tubules is later increased until about the sixth or seventh week in the human embryo when the mesonephros is fully developed. After this, degeneration occurs, so that the excretory duct and only a few small rudiments remain in the last half of embryonic life.

Metanephros.—The structure known as the ureteral bud takes its origin from an outgrowth from the excretory ducts near their junction with the cloaca. At first a solid process of cells springing from the dorsal surface of the excretory duct, the ureteral bud elongates in a cephalic direction, acquires a lumen, and is then known as the ureteral duct. It is in fact the beginning of the ureter, and appears about the twenty-second day. Its anterior or cephalic end becomes enlarged with the formation of several lobes called renal vesicles (McMurrich, Development of the Human Body, 1907), and does not reach its final embryonic position before the third month. From the so-called renal vesicles at the cephalic end of the ureteral duct an outward formation of tubules continues. These tubules also have vesicular-like extremities from which other tubules branch, and in a similar manner, by a regular process of division, secondary, tertiray, and even quaternary tubules are formed, all communicating with the renal vesicle from which they are derived. This outward formation of tubules continues until these structures come into contact with secreting tubules and vascular convolutions which have been undergoing development in the mesoblastic tissue of this region. The tubules arising from the renal vesicles

represent the system of collecting tubules of the kidney, and whether they, as well as the ureteral bud from which they develop, may or may not be considered as of ectodermic origin depends on the view taken regarding the origin of the lower portion of the excretory duct, from which the ureteral bud has its origin. There can be no question, however, as to the mesoblastic origin of the secretory tubules and of the vascular convolutions which meet the advancing collecting tubules of the metanephros. The union between the collecting tubules and the secretory tubules is not clearly understood. That the two systems do coalesce, so that the collecting tubules become the excretory channels for the urine secreted by the glomeruli and secretory tubules, is readily understood, but authorities differ as to how the junction of the two systems is effected. When the secretory tubules for any reason fail to join with their corresponding collecting tubules, they do not always become functionless until dilatations have occurred at their blind ends, which normally should communicate with the collecting tubules. We have thus a plausible explanation for the occurrence of a pathological condition, sometimes encountered, known as polycystic kidney. This subject will be given further attention in a later paragraph. The capsules of Bowman are formed entirely from the mesoblastic tissue of the nephrogenic cord and may be considered as a portion of the walls of the secretory tubules, which become very thin and in which the vascular glomeruli invaginate themselves until surrounded entirely by the thin capsular wall, except at the point where the afferent and efferent vessels enter. As the tubules elongate, the glomeruli are carried deeper into the surrounding cellular portion of the mesoblast, which forms the anlage of the cortical portion of the metanephros. The metanephros has no pelvis up to the time when the tubules begin to develop from the lobulated ends of the ureteral duct. This duct extends well forward to the central portion of the metanephros before it branches into its lobulated extremities. An evagination of these branches later forms a common cavity, and this process of evagination continues until the more central of the secondary and tertiary collecting tubules arising from the renal vesicles are also taken into the cavity, and thus the collecting tubules to a large extent eventually open directly and separately into the cavity. The main portion of this cavity becomes the renal pelvis. At its periphery, where it is subdivided into branching processes extending to the various groups of orifices of the collecting tubules, these smaller subdivisions become the calices of the renal pelvis. As many as 100 collecting tubules may open into the hilum of the kidney.

At about the tenth week in the human embryo, the metanephros presents a lobulated appearance, the outer surface presenting the outline of about 18 closely grouped lobules, each one corresponding to a group of tubules leading to the same renal vesicle. Normally in man, this lobulation disappears soon after birth when the transformation of the metanephros to the true kidney becomes complete.

Another step in this transformation, which has proceeded simultaneously with the changes in structure, is the gradual migratory ascent of the metanephros and a corresponding lengthening of the ureteral duct. Beginning near the lower extremity of the excretory duct of the mesonephros, in a position corresponding to the sacral region and below the bifurcation of the aorta, the ureteral bud and the appendages which develop from it, as well as the secretory tubules and glomeruli, which enter into the formation of the metanephros and later of the true kidney, gradually migrate in a cephalic direction dorsal to the caudal end of the mesonephros, as long as it persists, until at birth they have nearly reached the fossa renalis where the kidney is found in adult life. In this change of location we have an explanation of certain malpositions of the kidney which sometimes give rise to surgical indications. It is hardly necessary to state that the course of development which has been described applies to each kidney, the process being duplicated. The development of the two sides of the body occurs in a similar manner as far as the structures which have been described are concerned, and at the beginning of the development of the metanephroi these organs lie in close proximity in the sacral region. The condition known as horseshoe kidney, to be described later, may be considered as due to a fusion of the anlagen of the metanephroi while occupying their pelvic position. The migration of the kidney necessitates a gradual corresponding change in its vascular supply, and while, at the beginning, branches from the common iliacs or the middle sacral artery may be considered to be the nutrient arteries, the permanent blood-supplying vessels which are direct branches of the abdominal aorta in the lumbar region become the true renal arteries. The variation in number and distribution of the permanent renal arteries has an embryological explanation which will be mentioned in the paragraphs devoted to the applied anatomy of the kidney.

Important changes occur in the caudal end of the mesonephric duct from which the ureteral bud takes origin. With the development of the floor of the bladder the ureters acquire openings in the bladder wall independent of the mesonephric ducts. This subject is best handled

in a consideration of the development of the bladder. The mesonephric ducts in the male take part in the formation of the ejaculatory ducts and the vasa deferentia, and in the female remain as vestigial structures in the broad ligaments known as the canals of Gaertner.

ANATOMY OF THE KIDNEY AND URETER

In the adult the kidney averages 10 to 12 cm. in length, 5 to 6 cm. in width, and 3 to 4 cm. in thickness (Fig. 137). The weight is

Fig. 137.—Normal kidney.

usually between 130 and 150 grams. The upper pole of the kidney is nearly 1½ in. nearer to the mid-line of the body than the lower

pole, the long diameter of the organ extending somewhat obliquely outward and downward corresponding to the direction of the twelfth rib, which is in close relation to the kidney posteriorly. The right kidney occupies a position slightly lower than the left. The outer margins of the kidneys correspond topographically with points on the surface of the body ½ in. outside the erector spinæ muscles. On the right side the lower pole is 1 in. above the iliac crest at the level of

FIG. 138.—Normal kidney divided longitudinally. *a*, Artery; *b*, cortical portion; *c*, cortical columns; *e*, capsule; *m*, medullary pyramid; *r*, renal papilla; *p*, pelvis of kidney; *v*, vein.

the upper margin of the third lumbar vertebra, and the upper pole 4 in. above this point and 1½ in. nearer the mid-line of the body, at the level of the upper margin of the twelfth dorsal vertebra. The pelvis of the kidney lies at the level of the transverse processes of the first and second lumbar vertebræ. The twelfth rib lies in close relation to the upper third of the right kidney; and on the left side, owing

to the somewhat higher position of the kidney, the rib covers its upper half. Palpation of the kidneys is thus rendered difficult.

The kidney is enveloped in a perirenal capsule composed of subperitoneal connective tissue continuous above with that of the diaphragm. In this connective tissue a large amount of fat is usually present in health (Fig. 138). This is especially noticeable about the lower pole of the kidney. This perirenal fat is less abundant in childhood than in adult life, and while most of it is within the fascial capsule of the kidney, a varying amount of fat is often present outside the capsule. The posterior surface of the fascial capsule is closely attached to the muscles which underlie it, and this attachment serves as an important factor in holding the kidney in position.

In its capsule the kidney lies in the so-called renal fossa formed by the surrounding muscular structures; the quadratus lumborum lies externally and the psoas major internally, and the crura of the diaphragm are also in close relation.

Anteriorly on the right side, the relations from above downward are: the lower surface of the right lobe of the liver, the descending or second portion of the duodenum, the commencement of the transverse colon and the ascending colon. Externally on the right side, the right lobe of the liver curves downward along the upper third of the kidney.

Anteriorly on the left side, the upper pole is in close relation to the fundus of the stomach, and below this are the tail of the pancreas and the descending colon or splenic flexure. Externally on the left side is the spleen.

The internal border of each kidney closely approximates the outer border of the psoas major muscle of the corresponding side. At the upper pole of each kidney will be found the suprarenal gland or capsule, and this structure is sometimes closely adherent to the kidney.

Crossing the posterior surfaces and extending obliquely downward and outward, branches of the last dorsal and first lumbar nerves, together with the iliohypogastric and ilio-inguinal nerves, will be encountered.

The peritoneum lies entirely anterior to the kidneys, and is not usually encountered in surgical operations upon the kidney through the usual lumbar incision.

A true capsule called the tunica fibrosa closely invests the kidney within the fascial capsule just described. This true capsule is composed largely of fibrous tissue, but contains a small number of involuntary muscular fibers, especially in the region of the hilum and about the

papillæ (sphincteræ papillæ). At the hilum, the outer layer of the capsule is continuous with the pelvis of the kidney. Blood-vessels and lymph channels connect the loose layer of fat about the kidney with the true capsule, and thus disease of the kidney can be communicated to the perirenal fat, and in this way perirenal abscesses sometimes take their origin. The kidney moves with the diaphragm and descends from ½ to 1 in. with each respiration. In health the fibrous capsule is easily stripped off with little bleeding, but in disease the capsule is often closely adherent.

The cortical portion (Fig. 138–*b*) of the kidney consists of a narrow outer strip about 1½ cm. in width from which prolongations extend toward the hilum. These prolongations have a somewhat striated appearance in the cut section and are known as the columns of Bertini (Fig. 138–*c*). Between these columns are the medullary pyramids (Fig. 138–*m*), about 15 or 20 in number with their apices directed toward the hilum. The apices of the medullary pyramids are closely grouped at the hilum, and the renal papillæ (Fig. 138–*r*) are formed by these apices as they project into the sinus of the kidney. The papillary ducts, 15 or 20 in number, open on each papilla (area cribrosa). One renal papilla may correspond to several medullary pyramids. At the hilum of the kidney the outer layer of the fibrous tissue of the capsule becomes continuous with that of the ureteral calices which surround each papilla. The epithelium of the calices is continuous with that covering the apices of the papillæ. The smaller calices correspond in number with the number of papillæ present, but they are very short and soon unite with others to form larger calices which may be from two to five in number, and these in turn merge in a common cavity, the pelvis of the kidney (Fig. 138–*p*).

The pelvis of the kidney narrows rapidly from the hilum downward to form the upper portion of the ureter with which it is continuous (Fig. 137). When the larger calices of the kidney do not soon unite to form the renal pelvis they may continue downward to form two or more ureters. These structures may remain entirely independent with separate orifices in the bladder, or they may unite at any point along their course and thus give rise to a bifurcated or branched ureter. The subject of double or multiple ureters will be considered more at length in the paragraphs on anomalies and malformations.

The nerve supply to the kidney comes from the sympathetic system chiefly through the lesser and least splanchnics, and from

the solar plexus. The vasomotor nerves are important factors in functional activity.

The renal arteries (Fig. 138–*a*) branch off one on each side of the abdominal aorta below the superior mesenteric and first lumbar arteries, on a level with the first lumbar vertebra. They pass transversely outward across the crura of the diaphragm to the kidneys, the right being on a slightly lower plane than the left and passing behind the inferior vena cava. In front of each is the corresponding renal vein

Fig. 139.—Cast of kidney pelvis.

(Fig. 138–*v*) and behind at the hilum of the kidney is the renal pelvis and commencement of the ureter. Each artery as it enters the hilum usually divides into three main stems, passing respectively to the upper, the middle and the lower portions of the pelvis. "Each of these primary stems then divides so that there result from seven to nine secondary branches, the majority of which pass anterior to the pelvis, while the remainder are posterior to it. No anastomoses

take place between the branches of the anterior and posterior secondary stems, and hence a longitudinal incision into the kidney along its curved border will cut only terminal arteries" (Sabin, in Morris' Human Anatomy, 1907, ii, 593). This relatively non-vascular zone is called by Byron Robinson the "exsanguinated zone of Hyrtl," since its existence was pointed out by Hyrtl, and it is of surgical importance as being the area of least hemorrhage when it becomes necessary to divide the kidney.

It is now believed that the blood-vessels supplying the mesonephros in embryonic life are intimately concerned in the vascularization of the metanephros, and variations in the number and distribution of renal arteries are understood more clearly when it is recalled that the mesonephric tubules develop in segmental formation, each segment being supplied with a blood-vessel which extends in a transverse direction directly from the aorta to its proper segment. As the metanephros migrates upward dorsal to the mesonephric vestiges, and as the reproductive glands begin their descent toward the pelvis, a vascular network is formed from the mesonephric arteries in the more caudal portion of this segmented organ, and this vascular network serves as a blood supply to the metanephros and the reproductive glands. As the tubules of the mesonephros degenerate, the atrophy of the arteries supplying them depends on whether or not, through the vascular network above described, they have become factors in supplying blood to the kidney and to the ovary or testis. In the case of the kidney, it frequently happens that these mesonephric arteries, one or more in number, persist to become accessory renal arteries, and their distribution is subject to considerable variation. During the upward migration of the organ these vessels may become aberrant in their course so that they do not pass in a directly transverse direction to the kidney. It may happen that an aberrant renal vessel will not enter the substance of the kidney at the hilum as do the true renal vessels. If in its course such an aberrant vessel lies closely upon the ureter or pelvis of the kidney, it may cause distention of the latter as urine is excreted into it, with resulting hydronephrosis.

The renal veins are short but thick and open into the vena cava nearly at right angles to that vessel. Like the kidney, the vein on the left side is slightly higher than on the right and is also longer, in consequence of its having to cross the aorta. Each vein lies in front of its corresponding artery. The left vein crosses in front of the aorta, just below the origin of the superior mesenteric artery. It is covered

by the third portion of the duodenum, and receives the left spermatic vein, or the left ovarian in the female, and usually the left suprarenal and sometimes the left phrenic.

The lymph channels of the kidney empty into the chain of lumbar lymph nodes. During their course smaller nodes may be present, lying in close relation to the renal blood-vessels.

Ureter.—The upper expanded portion of the ureter has already been described as the pelvis of the kidney, which serves as a common cavity into which the ureteral calices merge. The renal pelvis curves downward as it leaves the hilum of the kidney and becomes contracted like a funnel, until at the level of the lower pole of the kidney it has the appearance of a cylindrical tube. Including the pelvis of the kidney the ureter averages from 25 to 30 cm. (10 to 12 in.) in length, extending in a caudal direction to its orifice in the bladder wall.

The wall of the ureter consists of three layers, an inner layer of mucous membrane lined by transitional epithelium, a middle muscular layer, and an outer layer of fibrous tissue. The muscular layer consists of involuntary muscular fibers with annular fibers without and longitudinally disposed fibers within. The lumen averages ½ cm. in diameter, but there are three constricted portions, the first located just below the renal pelvis, the second at the brim of the true pelvis, and the third immediately above the entrance of the ureter into the bladder.

Throughout its entire course each ureter is retroperitoneal. The portion which lies within the abdominal cavity is almost straight where it lies upon the psoas muscle, but on entering the true pelvis it curves in a downward and inward direction along the lateral wall, and again ascends to the dorsal side of the bladder in order to pass to its opening in the bladder wall. On the right side, the close relation of the ureter to the inferior vena cava should be mentioned, this large vessel lying in close apposition to the ureter on its mesial side. The ureters cross the genitocrural nerves in the lumbar region, a fact which may explain the reflex pain which sometimes occurs in the testicle in cases of stone in the ureter.

The ureters are bound to the parietal peritoneum by fibrous tissue. They cross the iliac vessels as they enter the pelvis. As they approach the bladder they are crossed superiorly and internally by the vas deferens and then pass under the free extremity of the seminal vesicle, at which point each is separated from its fellow by a distance of 3.7 cm. (1½ in.). In the female, in their lower course, each ureter runs parallel to the cervix uteri, passes behind the uterine artery, through the uterine plexus

of veins and beneath the root of the broad ligament, and finally crosses the upper third of the wall of the vagina to reach the vesicovaginal interspace and enter the bladder wall opposite the middle third of the vagina. A calculus in the lower end of the ureter may thus sometimes be detected by a vaginal examination.

The vesical portion of each ureter is about ½ in. in length and runs obliquely downward and inward through the coats of the bladder until it opens on the mucous surface from ¾ to 1 in. from its fellow and about this distance from the urethral orifice. The arteries which supply the renal pelvis and the upper part of the ureter come from the renal vessels, the rest of the abdominal portion of the ureter being supplied by the spermatic or ovarian arteries according to sex, while the pelvic portion receives branches from the middle hemorrhoidal and inferior vesical arteries. The nerves are supplied by the spermatic, renal and hypogastric plexuses. The lymphatics pass to the lumbar and hypogastric nodes (Sabin, in Morris' Human Anatomy, 1907, II, 733).

MALFORMATIONS AND ANOMALIES

The following classification of congenital anomalies of the kidney has been proposed by W. A. N. Dorland (Surg., Gynec. & Obst., 1911, xiii, 303–319).

I. Variations in form and size.
   - (*a*) Lobulation.
   - (*b*) Hypertrophy of one kidney.
   - (*c*) Atrophy of one kidney (rudimentary kidney).

II. Variations in number-
   - (*a*) Absence of both kidneys.
   - (*b*) Absence of one kidney (aplasia)—single, solitary, unilateral or unsymmetric kidney.
   - (*c*) Presence of more than two kidneys (supernumerary).

III. Variations in location (dystopic or ectopic kidney).
   - (*a*) Right- or left-sided double kidney (non-fused).
   - (*b*) Mural kidney.
   - (*c*) Pelvic kidney.

IV. Fusion of the kidneys.
   - (*a*) Horseshoe kidney.
   - (*b*) Sigmoid kidney.
   - (*c*) Disc-shaped or placentoid kidney.

V. Variations in the pelvis, ureters and blood-vessels.

One or more of these anomalous conditions may be present in the same subject. Only those of surgical interest will be discussed.

Congenital hypertrophy of one kidney is usually compensatory in its nature, the other kidney being atrophic or entirely absent. The enlarged organ may be equal to two normal kidneys and, as has been pointed out by F. Craven Moore (Studies in Anatomy, 1906, iii), the congenital type of compensatory hypertrophy is due largely to an actual increase in the secretory apparatus of the kidney, the glomeruli and secretory tubules, with no apparent increase in the number or size of the collecting tubules. Compensatory hypertrophy of one kidney, when due to a diseased condition of the other kidney which occurs after development is complete, consists in the enlargement of the glomeruli and convoluted tubules, without increase in their number. Moore (*loc. cit.*) states that the two forms of compensatory hypertrophy are in accordance with what appears to be a general biological principle, viz., that a persistent demand for increased functional activity, made on any structure during its developmental stage, is met by a corresponding increase in the production of the functionating elements, while such a demand, when it is made after the cessation of development, is met by an increase in the size of the individual elements.

Absence of one kidney is among the least common of renal anomalies. The condition is known by a variety of terms such as single, solitary, unilateral, or unsymmetrical kidney, by which is understood an angenesis or aplasia of the kidney on one side. From autopsy findings Moore (*loc. cit.*) concludes the frequence of this anomaly to be about 1 in 2400 autopsies. No satisfactory figures are available to indicate the frequency with which this condition has been met in clinical work, but cases of true single kidney are extremely rare.

The migratory change from a sacral to a lumbar position, which takes place during the developmental stage of a normal kidney, sometimes gives rise to abnormal locations of the organ. Such abnormal locations may affect but one kidney while the other is in its normal situation, or both may be displaced. The degree of congenital displacement may vary from a position somewhat lower in the lumbar region than the normal position, to complete pelvic ectopia, in which case the kidney remains in its early embryonic position. Such malposition of the organ is accompanied by great variations in the blood supply and in the course of the ureters. Ectopic kidney may give rise to no symptoms during life. When the condition does cause disturbance this is

usually brought about by the pressure of the misplaced organ on the surrounding viscera.

Fusion of the Kidneys.—Fusion of the kidneys is a renal anomaly which is not uncommon and which may sometimes give rise to serious conditions. During embryonic life the anlagen of the kidneys are in close relation in the sacral region and at this time fusion is most likely to occur. The organs may unite completely thus giving rise to the disc-shaped or placentoid kidney; the upper pole of one organ may fuse with the lower pole of the other, when the condition is termed sigmoid kidney; or two kidneys may unite at the superior or inferior poles only, forming the variety of fused kidneys known as horseshoe kidney.

Horseshoe Kidney.—Botez (J. d.'urol. méd. et chir., 1912, i, 193) who has recently made an exhaustive study of horseshoe kidney, succeeded in collecting reports of 320 cases found at autopsy or at operation. Only 16.25 per cent. of this number were diseased. In 51,504 autopsies, 72 cases of horseshoe kidney were found, an average of one in 715 autopsies. It was Israel (Zentralbl. f. Chir., 1904, xxxi, 302) who in 1900 first diagnosed a case of horseshoe kidney before operation and called attention to the possibility of making a diagnosis by means of palpation. In order to diagnose the condition it is necessary to have constantly in mind the possible existence of this malformation, and to palpate with the object of determining whether or not it may be present. Today the number of surgeons who have made a diagnosis of horseshoe kidney before operation is still very small (Botez, *loc. cit.*), and yet this anomaly must be considered as one which presents a very characteristic morbid picture and one of great clinical importance.

A horseshoe kidney which is not diseased may give rise to certain abnormal physical or psychical conditions. Martinow and Rovsing (Zentralbl. f. Chir., 1910, xxxvii, 314–316; Ztschr. f. Urol., 1911, v, 588) have proposed a radical treatment for undiseased horseshoe kidney when it gives rise to symptoms of sufficient importance. This treatment consists of a complete division of the renal isthmus between the two lobes so that the fused kidney is transformed into two separate organs. This operation has been so well demonstrated that it may be considered as a very brilliant conception of the surgery of horseshoe kidney. All cases of undiseased horseshoe kidney, however, do not give rise to symptoms, and the greater number of cases do not manifest themselves during life and are found only at autopsy. On the other hand, clinical observation has demonstrated that cases do occur in which this anomaly has been the cause of disturbances which are sometimes extremely grave.

The symptoms or physical signs of an undiseased horseshoe kidney may be caused by the shape of the organ, by its usual low situation, by its mobility, or by the compression which it exercises on the other abdominal viscera.

As a rule the two renal elements are fused at the lower poles, and are situated one on each side of the vertebral column with the isthmus between. The organ in its entirety, or at least one of its lobes, is situated lower and nearer the mid-line than the normal position. An abnormal fixation is usual. Some horseshoe kidneys are fixed by their superior poles while the isthmus remains mobile; in other cases the two renal lobes are completely movable while the isthmus is bound to the vertebral column. It is not unusual to find the organ in an ectopic situation, and it may present all degrees of abdominal or pelvic ptosis.

The operative frequency of diseased horseshoe kidney is greater than that shown by autopsy records. While the occurrence of those found at autopsy is one in 715, Israel found five cases in 800 operations, and Marion two in 200 operations, or an average of one in 143 operations (Botez, *loc. cit.*).

The causes of the predisposition of horseshoe kidney to diseases are numerous. The lobes of a horseshoe kidney are rarely equal in size, in the great majority of cases one being hyperplastic while the other is hypoplastic. In addition this morphological anomaly is very often associated with other anomalies; the vessels may be abnormal in situation or number; the kidney pelvis may be abnormally placed, or there may be a vicious implantation of the ureter on the pelvis; the mobility of the organ also may predispose to different maladies.

Botez (*loc. cit.*) summarizes the ages in 43 cases of diseased horseshoe kidney as follows:

5	Cases	Age	1–10 Years	10	Cases	Age	40–50 Years.
7	"	"	10–20 "	4	"	"	50–60 "
11	"	"	20–30 "	1	Case	"	60–70 "
5	"	"	30–40 "				

46 cases 29 were in males and 17 in females.

All of the diseased conditions which attack normal kidneys are found in horseshoe kidneys, including contusions, pyelonephritis, pyonephrosis, tuberculosis, tumors, cysts, calculi, hydronephrosis, hydropyonephrosis, displacements, etc.

Symptoms of Horseshoe Kidney.—The symptoms of horseshoe kidney depend upon its location and upon the presence or absence of an accompanying diseased condition of the organ.

A. Symptoms of Undiseased Horseshoe Kidney.—1. When the situation of the horseshoe kidney is in the lumbar region, but below the location of the normal kidney, the most common location of this anomaly.

(*a*) *Functional Symptoms.*—Pain of a sharp oppressive character, persisting for some time without relief, may be the leading symptom. This pain is located in the loins and lower abdomen and may cross from one renal region to the other. Its principal characteristics are its intermittent occurrence, and the fact that it may be produced by provocation. It disappears when the patient is at rest, reappears under bodily fatigue, and is particularly noticeable when the patient bends backward as when lifting heavy objects.

Digestive disturbances are present and are characterized often by an obstinate pyrosis which is brought on by no particular kind of food. There may be repeated vomiting after each meal or, during the occurrence of the painful crises (Porter, Boston M. and S. J., 1903, cxlviii, 367; Rovsing, Ztschr. f. Urol., 1911, v, 589), there is sometimes a dyspepsia which is permanent and does not yield to dieting (Oliver, Brit. M. J., 1898, i, 552); very rarely constipation is present (Martinow, Zentralbl. f. Chir., 1910, xxxvii, 314–316).

Nervous ailments of an hysterical or neurasthenic character almost always accompany the existence of this anomaly.

These three functional symptoms, pain, digestive disorders and nervous phenomena, are quite constantly associated when the undiseased horseshoe kidney is not quiescent.

In addition to these disturbances Martinow calls attention to disagreeable pulsatile sensations in the whole abdomen, which sometimes disturb patients who are afflicted with this anomaly.

These functional and mental disturbances are considered to be the result of the reciprocal compression of the kidney and the neighboring organs. The anomalous kidney lies close to the anterior surface of the vertebral column, being separated therefrom by the aorta, the inferior vena cava, and the nerve plexuses only. As a result, all fatiguing movements or any excessive exertion may result in the compression of these structures between the renal isthmus and the vertebral column. When the two superior renal poles are more or less solidly fixed, while the isthmus is more or less movable, it can readily be understood how any unusual movement of the vertebral column backward or forward may press the horseshoe kidney more closely against the vertebræ, thus giving rise to the characteristic pain (Rovs-

ing, *loc. cit.*). In the same way the large vessels and nerves may be compressed between the renal isthmus and the vertebral column. The pressure on the nerve plexuses alone can explain the digestive and nervous phenomena which characterize the presence of this anomaly. It has been asserted that compression of the large vessels might give a consequent thrombosis of the large veins (Neufville, Archiv f. physiol. Heilk., 1851, x, 276) especially of the inferior vena cava, or might cause the formation of an aortic aneurism (Morgagni, Botez, *loc. cit.*).

(*b*) *Physical Symptoms.*—Inspection usually furnishes no information. In a few cases, however, a distinct pulsation in the umbilical region has been noted. This is nothing more than the pulsation of the aorta which is transmitted by the renal isthmus (Martinow, Oliver, Sandwith, Burghardt, in Botez, *loc. cit.*).

Percussion, practised with the aid of the phonendoscope, especially after insufflation of the intestine, may render service by outlining exactly the situation and the form of the organ.

Palpation is the best means of exploration, notwithstanding the fact that the undiseased horseshoe kidney often fails to give any definite sign of its presence by this method of examination. This should be not alone renal palpation, but renal palpation associated with abdominal palpation. By careful palpation it is possible in the majority of cases to discover that the kidneys are not normally situated but are lower and nearer the median line, and that the inferior part of one or of both kidneys extends toward the vertebral column. It may be possible to make out a tumor, which in the region of the right or left flank, prolongs itself inward and across the vertebral column. Only in thin or emaciated individuals, however, is one able to discover by palpation the entire outline of the horseshoe kidney. Before attempting an examination the intestines should be thoroughly evacuated.

Auscultation sometimes reveals a bruit or souffle above and more often below the abdominal tumor.

The urine gives no indication of the presence of undiseased horseshoe kidney and the urinary function is entirely normal.

2. When the situation of the horseshoe kidney is abdomino-pelvic or pelvic, a somewhat different chain of symptoms characterizes its presence.

(*a*) *Functional Symptoms.*—Pain is the principal symptom, but is variable in severity. It may vary from simple uneasiness to pain which is so severe as to resemble the crises of movable kidney. It is located

chiefly in the large or small pelvis and radiates downward into the lower extremities, while sometimes it may become localized in the sacral region.

Digestive disturbances may be observed which are analogous to those which accompany a horseshoe kidney in the lumbar region, but these are less apt to be reflex in character and in a majority of cases are caused by the direct compression of the rectum, which causes obstinate constipation, or an alternating diarrhœa and constipation.

Nervous disturbances are likely to be present. In a female, the horseshoe kidney in a pelvic situation may, by its compression upon the uterus, lead to abortion or may cause dystocia. Persistent amenorrhœa or pronounced dysmenorrhœa may also occur.

(*b*) *Physical Symptoms.*—Palpation is the most reliable means of exploration. When no tumor is perceived on abdominal palpation the examination should be continued by using the bimanual method with an examining finger in the rectum in the male, and in the vagina or rectum in the female, with pressure over the pelvis. The tumor formed by the abnormal organ may thus be felt, but it is often difficult to determine whether the tumor thus felt signifies a horseshoe kidney or a neoplasm.

Urinary difficulties are usually absent.

B. Symptoms of Diseased Horseshoe Kidney.—A silent horseshoe kidney may reveal itself at any monent if it is attacked by disease, and as has already been stated, the anomalous organ is subject to the same maladies as those found in the kidney of normal morphology.

The intensity of the functional symptoms depends upon the situation and fixity of the organ as well as upon the nature of the malady. The malady may so dominate the clinical picture as to prevent one from suspecting the presence of a horseshoe kidney. Israel (Zentralbl. f. Chir., 1904, xxxi, 302) has called attention, however, to certain physical signs which nearly always characterize the symptomatic picture of diseased horseshoe kidney. His assertions are more readily appreciated when it is considered that a diseased horseshoe kidney usually has larger dimensions than one which is not diseased, and that as a consequence it should be more readily approached by all the means of physical exploration which we possess.

According to Israel (*loc. cit.*) palpation may give complete or incomplete results. In the first instance the organ may be palpated in its entirety and there remains no doubt of the existence of the anomaly. This is possible only when the subject is emaciated, has a very supple

abdominal wall, and when the intestine is empty. In many cases, on the other hand, the exact contour of the organ cannot be discovered by palpation. The general character of the abdominal tumor, however, may be sufficiently determined to make possible an accurate surmise as to the true condition. If separation between the two lobes be noted, then an idea of the entire form of the organ may be secured if by imagination one completes the interrupted contour. An examining finger in the rectum or vagina combined with abdominal palpation is of service when the organ is ectopic.

In a number of cases the diagnosis of horseshoe kidney is almost impossible because palpation, one of the surest means of diagnosis, is negative. Especially in the case of undiseased horseshoe kidney is one more apt to disregard an abdominal tumor than to consider it a horseshoe kidney. Nevertheless, the knowledge of this anomaly which we possess today is much greater than a few years ago when horseshoe kidney had been found only at autopsy or as a surprise at operation. It must not be forgotten that in order to diagnose this anomaly, it is necessary to look for it! It is necessary to have it in mind when one palpates the abdomen. In cases of doubt palpation under anæsthesia is indicated.

One other means of diagnosis which, at least, is as sure as palpation, if not more so, is radiography. This enables us to surmise the presence of this anomaly when we can distinguish an intermediary portion between the two kidneys, but it furnishes a more exact key to diagnosis when it is used in connection with pyelography by means of either the cautious injection of collargol into the ureters and pelvis, or the catheterization of the ureters with catheters impermeable by X-rays. One is thus enabled to determine not only the situation of the kidney, but also small dilatations of the pelves and the calices, as well as anomalous situations of the ureters. This form of exploration reveals the general characteristics of a horseshoe kidney in which the pelves and ureters are nearer the mid-line of the body than is normally the case. Finally, the radiograph may sometimes give us indirect indications when it reveals the existence of renal calculi in an abnormal median position.

Treatment.—All horseshoe kidneys which occasion any acute symptoms whatever are justifiably treated surgically. It is necessary, however, to make proper distinction between the treatment of undiseased horseshoe kidney, and the treatment of diseased horseshoe kidney.

A. Treatment of Undiseased Horseshoe Kidney.—According to Rovsing (Ztschr. f. Urol., 1911, v, 586–589) the treatment of a horseshoe kidney, which is undiseased but which causes any trouble whatever, should be undertaken for all patients in whom manual labor is a necessity. An early operation will result in the transformation of the fused kidneys into two nearly normal organs, the ideal operation in these cases being the complete division of the isthmus.

Regarding the choice of incision Rovsing claims that the operation cannot be performed by the usual lumbar route; for he says "there exists a great difference between extirpation of a single kidney and the division of the isthmus with conservation of the two lobes. In extirpation after ligature the vascular pedicle and the ureter are cut and one has free access to the region of the isthmus; in the case of division of an uncomplicated horseshoe kidney it is necessary to manage the ureter, the pedicle, and the kidney together." Other contraindications to the lumbar route are the facts that the incision does not give sufficient space and light for the operation to be safely performed and that by it one cannot liberate and completely deliver the kidney. Moreover, on account of the usual abnormal position of the ureters, they are exposed to damage by this incision as are also the great vessels, the aorta and inferior vena cava, which are immediately behind the isthmus, the portion of the organ which it is necessary to incise. For all of these reasons the transperitoneal route is to be recommended.

Rovsing (*loc. cit.*) gives the following technique for the operation:

Step 1.—Perform a laparotomy and displace the intestinal mass to one side or the other.

Step 2.—Incise the parietal peritoneum outside the colon and the duodenum and lay bare the renal isthmus by uncovering and turning aside the peritoneal coat.

Step 3.—When the isthmus is fibrous or membranous the only further procedure is to divide it with scissors between two clamps and to ligate the two parts. When the isthmus is parenchymatous, however, and thus more or less thickened, it is necessary to grasp it slowly with a large angiotribe until it becomes reduced to its outer membrane, and then to section this membrane between two clamps and to suture the two edges by a continuous catgut suture.

Step 4.—Suture the posterior peritoneum and close the abdominal wound. When there is much oozing counterdrainage should be employed through the lumbar regions.

B. Treatment of Diseased Horseshoe Kidney.—The treatment of diseased horseshoe kidney is in principle the same as the treatment of non-anomalous diseased kidneys, although without doubt some operative procedures when applied to horseshoe kidney must be modified in their technique and perhaps sometimes may be contraindicated.

In the large majority of cases, probably 90 per cent., if the horseshoe kidney has not been diagnosed before operation, its lobes will be exposed by the classical lumbar incision. In such a case it is very important to recognize the presence of the anomaly; that is, to make an operative diagnosis.

The diagnosis will be indicated by the presence of the following conditions:

1. The pelvis in the antero-inferior abnormal situation.
2. The ureter leaving the anterior wall of the pelvis, more or less high, and descending on the anterior surface of the kidney.
3. An abundant and abnormal vascularization.
4. The exposed lobe in a situation lower and nearer the mid-line than in a normal kidney.
5. The posterior surface of the kidney enclosed, in large part, by the posterior peritoneum, because of the more median location.
6. The impossibility of liberating the lower pole of the kidney.

If these conditions are found during a renal intervention, they should always arouse the suspicion of a horseshoe kidney. Cases are on record where it has been impossible to finish an operation because the existence of this anomaly has not been recognized (Braun, Deutsche med. Wchnschr., 1881, vii, 422—Schuchardt in Berl. klin. Wchnschr., 1892, XXIX, 833). Having diagnosed the anomaly during operation, the lumbar incision should be prolonged and thus transformed into a lumbo-abdominal incision.

Although the two lobes of a horseshoe kidney may be exposed by a single oblique lumbo-abdominal extraperitoneal incision, operative procedures involving both lobes require a lumbo-abdominal incision on each side (Israel, *loc. cit.*). In making the incision it is important to bear in mind the fold of peritoneum which covers a large part of the posterior surface of the renal lobe, as this may be easily wounded. This peritoneal fold must be pushed aside laterally in order to completely expose the fatty capsule, which in turn should be divided with great caution as in all cases of horseshoe kidney the fatty covering is but slight. When the renal lobe has been brought into view it remains only to bring it up into the wound in order to perform the indicated

operation. Since the horseshoe kidney often has abnormal adhesions, the liberation and delivery of one of its lobes is often more difficult and incomplete than is the delivery of a normal kidney. On the other hand the lobes of a horseshoe kidney may be so completely separated that one lobe may be completely delivered without bringing into view the other lobe or ureter.

On account of the anatomical modifications of the pelvis, a pyelotomy on a horseshoe kidney becomes a more delicate operation than one performed on the normal organ. As has already been noted the liberation and delivery of a lobe of a horseshoe kidney is difficult and incomplete in the majority of cases because of the fixation produced by the isthmus and by numerous vascular pedicles which are often very short; the difficulty of delivery is enhanced also by the situation of the pelves at the antero-inferior part of the lobes, a position which renders it almost impossible to expose the posterior surface of either pelvis. For these reasons pyelotomy on one of the pelves of a horseshoe kidney must be anterior and must be executed on a kidney not completely delivered.

Nephrotomy, which is one of the most serious operations on non-fused kidneys, becomes still more dangerous when performed on fused kidneys, which have nearly always an excessive vascularity. For this reason and because of the difficulty of complete delivery one should attempt nephrotomy only when pyelotomy will not suffice.

Nephrectomy, *i.e.*, the removal of one entire lobe, or in special cases partial nephrectomy is one of the most useful operations in cases of diseased horseshoe kidney. The indications for nephrectomy are the same as those in the case of separate kidneys with the following exceptions:

(1) Although in a horseshoe kidney there may exist two ureteral orifices which excrete urine into the bladder, one can never be sure that the two ureters excrete the urine secreted by equivalent portions of the renal parenchyma. For this reason the result of a nephrectomy may appear inconsistent with the results of the functional examination of kidneys. In other words functional examination may lead one to the attempt an intervention which at the time of its execution will be found impracticable.

(2) Whether or not the diagnosis of horseshoe kidney has been made, before operating one should always proceed as in the case of normal kidneys. A functional examination of the kidneys should be made; and should both lobes be more or less affected, operative intervention is contraindicated. If one of the lobes is not functionating while the other is active, one may be led to operate on the former. The

nature of the intervention is best decided after exposure of the organ. Before deciding upon operative procedure it is necessary always to take into account the development of both lobes and the possible existence of various anomalies of the ureters.

(3) In order to extirpate the renal lobe it is necessary to divide the isthmus. As this portion of the horseshoe kidney lies in close relation to the large abdominal vessels it is sometimes closely adherent to the vessels and its liberation becomes a very perilous undertaking.

Moreover, the incision of the isthmus itself demands careful consideration. If there are no notches or other landmarks by which to determine the respective limits of the two renal lobes, we cannot be sure that the incision is exactly between the two lobes, and one is apt, therefore, to remove too much or too little of the isthmus. While this point is not of special importance in the case of more benign affections, it becomes vitally so in the case of malignant growths or of tuberculosis.

(4) If one lobe of a horseshoe kidney has been removed, the situation and support of the remaining lobe will be but slightly influenced if its superior pole be fixed to the posterior abdominal wall; but when the horseshoe kidney is maintained in its position by the isthmus only, the remaining lobe may become more or less movable after the extirpation of its fellow. It is to prevent this mobility and its consequences that Albarran (Ann. mal. des. org. Genito-Urin., 1907, i, 809) conceived the idea of fixing the stump of the remaining lobe to the psoas muscle.

(5) Hemorrhage is sometimes a disturbing factor when the isthmus is parenchymatous instead of fibrous. This bleeding may be arrested by simple compression; cauterization with the thermocautery; partial clamping of the isthmus; suture of the wound or a portion of it after section; or finally, the use of ligatures on all bleeding vessels.

With these considerations in view, the excision of a lobe of a horseshoe kidney may be performed according to the following technique:

Step 1.—Expose the renal lobe and liberate it completely, including the isthmus.

Step 2.—Isolate, ligate and divide the vascular pedicles.

Step 3.—Divide the ureter.

Step 4.—Incise the isthmus, observing every possible precaution to avoid injuring the larger abdominal vessels, the incision being made at a right or at an acute angle according to preference. In order to assure hemostasis, the isthmus of the remaining lobe should be sutured throughout its entire extent with interrupted catgut stitches.

Step 5.—When necessary, the stump of the remaining lobe should be fixed to the psoas muscle.

Step 6.—Drainage should usually be employed because there may be not only hemorrhage but also some secretion of urine from the free surface of the isthmus.

Botez (*loc. cit.*) from whose admirable work most of the foregoing conclusions regarding horseshoe kidney have been drawn, summarizes 61 cases in which horseshoe kidneys were subjected to various surgical procedures with a mortality of about 20 per cent.

Anomalies of the Pelvis and of the Ureter.—Variations in the pelvis of the kidney and in the ureter are by no means rare, though no exact statements as to their frequency have been published, but the autopsy findings in a large series of cases seldom fail to disclose a number of these variations and the cystoscopic examination of the bladder often discloses anomalous conditions of the ureters.

The pelvis of the kidney may be displaced from its usual location at the inner border of the kidney and may lie anterior to the organ or at its external border. More than one pelvis may be present, each draining a separate portion of the kidney but uniting with the rest to form a common descending portion of the ureter. Whether the existing ureters are complete or partial, double or multiple, a separate renal pelvis will be found for each ureter, each one draining a separate portion of the tissue (Pawloff, *loc. cit.*). In such instances each renal pelvis is smaller than when only one is present, on account of the smaller number of ureteral calices which enter into its formation.

Two different types of double or multiple ureters exist, the incomplete or partial, and the complete. Each form has an entirely different embryological origin. The incomplete or partial double or multiple ureters do not extend to the bladder with a separate orifice for each in the wall of this organ, but the ureters unite at some point along their course to enter the bladder by a single orifice. Such ureters arise from fission or bifurcation of the single ureteral duct in embryonic life and while this may be looked upon as a normal process during the development of the ureteral calices in the embryo, it should be recalled that normally this stage is followed by the merging of the larger calices into a common cavity to form the renal pelvis which is continuous below with but a single ureter. When the process is arrested in the course of development so that all the ureteral calices do not finally unite, bifurcation of the ureter persists with a lengthening of each branch as the kidney migrates in a cephalic direction to the fossa renalis.

When the double or multiple ureters are distinct and independent throughout their whole extent, their origin must be from the embryonic development of more than one ureteral bud at the caudal end of the mesonephric duct. Such a condition is looked upon by Felix as an indication of reversion to a lower type of animal life. Two ureters from one kidney are not rare, and Bransford Lewis has reported a case in which three were present. Accessory ureters in themselves require no surgical attention, but their presence may often give rise to error when a renal diagnosis is made by means of ureteral catheterization. They furnish also a predisposition to pyelitis or pyelonephritis. When two or more ureteral orifices are present on one side in the bladder wall, the one most caudad extends to the uppermost pelvis of the kidney (W. Felix, in Keibel and Mall., *loc. cit.* A. Pawloff in Deutsche Ztschr. f. Chir., 1913, cxxi, 425). The presence of double or multiple ureters may be recognized during a cystoscopic examination of the bladder by pyelography by means of opaque ureteral injection followed by an X-ray examination or by finding more than one ureteral orifice in cases in which the ureters are complete.

An interesting case of congenital renal and ureteral anomaly was recently reported by Rolleston (Brit. J. Child's Dis., 1913, x, 161). This was an asymmetrical kidney with partial duplication of the ureter, coexisting with a patent ureter on the side on which the kidney was absent. He (Rolleston) states that out of 286 cases collected by Anders there were only 24 in which a more or less rudimentary ureter was present on the side on which the kidney was absent. In the majority of these the ureter was impervious and he was able to find only six other cases in which the ureter was patent throughout its entire length.

The orifice of the ureter sometimes varies in location. Rare cases have been reported with an ureteral orifice in the urethra; in the vas deferens; in the seminal vesicle; in the ejaculatory ducts; and in the vestibule in the female (Pawloff, *loc. cit.*).

Cases of congenital stenosis and stricture of the ureter have been encountered, the cause of which must be ascribed to fœtal conditions. The lumen of the ureter may be narrowed or entirely closed at any point throughout its extent, or there may be no lumen whatever. In the former case the condition usually gives rise to marked dilatation above the constriction with hydronephrosis and atrophy of the kidney. Eisendrath (Ann. Surg., 1912, lv, 571–592) and Bottomley (Ann. Surg., 1910, liii, 597) have summarized a number of cases of this type, nearly

all of which gave rise to symptoms before adult life. The symptoms vary with the location of the stenosis. When the stenosis is near the bladder wall it may be possible by abdominal palpation to discover the sausage-shaped tumor formed by the dilated ureter. On cystoscopic examination a protruding cyst-like formation may be observed in the region where the normal ureteral orifice is commonly found.

The treatment of ureteral stenosis consists in either ureterostomy or nephrectomy with ureterectomy. Cases in which ureterostomy has been undertaken have rarely succeeded (Eisendrath, *loc. cit.*).

Usually, however, the absence of a vesical orifice of the ureter on one side may be taken as evidence of aplasia of the kidney on the same side. On the other hand, cases have been described by Moore (*loc. cit.*), Todd (Anat. Anzeiger, 43 Band, No. 2, 1913), Rolleston (*loc. cit.*) and others in which a ureter of varying length was coexistent with aplasia of the kidney on the same side, the ureter having a blind extremity.

THE PHYSIOLOGICAL FUNCTION OF THE KIDNEYS

Only a brief discussion of the physiological function of the kidneys will be attempted.

The long-standing theories of Bowman and of Ludwig on the method by which the kidney secretes urine each has its adherents, and each has a place in textbooks on the subject. It may be considered as certain, however, that physical facts alone do not suffice to explain the urinary function of the kidneys, and much depends on the functional activity of the secretory cells of the renal parenchyma. This cell activity is affected by various factors, some of which are extrarenal and others intrarenal. Variations in blood pressure, for example, produce marked variations in the amount and in the kind of urine secreted, which may be enumerated as follows:

First, an increase in the total content of the vascular system with coincident increase of tension causes an increase in the amount of urine. When the pressure exceeds a certain level, albumin may pass from the blood into the urine. Conversely, a diminution of the vascular contents, by sweating, by diarrhœa, or by venesection, will cause a diminution in the amount of urinary secretion. During ureteral catheterization, a flow of urine may be induced by the copious drinking of water.

Second, diminution in vascular capacity will operate in a similar manner. The contraction of the cutaneous vessels caused by a cold;

the stimulation of the vasomotor center, or of considerable portions of the vasomotor nerves; the ligation or compression of arteries of large size; the application of tight bandages to the extremities, all give an increase in the amount of urine secreted under normal conditions. On the other hand, any conditions which increase vascular capacity will be followed by a reduction of the urinary secretion.

Third, increased cardiac activity, with consequent increased tension and increased rapidity of flow of the blood stream in the arteries, augments the amount of urinary secretion while, on the other hand, cardiac enfeeblement diminishes it.

The researches of Abeles and I. Munk (Landois, *loc. cit.*) would indicate that urinary secretion does not depend on any extrarenal control excepting the supply of blood and the vascular tension. These workers caused arterial blood to circulate through fresh living extirpated kidneys, pale urinous fluid escaped from the ureters drop by drop. Various organic and inorganic salts were injected into the circulating blood in these experiments and were promptly excreted in the urine from the extirpated kidneys (Landois, *loc. cit.*).

Recently Asher and Pearce (Am. J. Physiol., 1914, xxxv, 151) and later Pearce (Cleveland M. J., 1914, xiii, 861) have shown by experimentation that stimulation of the vagus nerve after section of the splanchnic nerve caused an increase in the flow of urine.

We quote from Pearce: "However, our experiments are open to criticism that the stimulation of the vagus after section of the splanchnic might result in a vasodilation of the vessels of the kidney, and account for the diuresis observed. To my knowledge this had not been tested experimentally and a series of experiments, under the same conditions which produce the increased urine secretion during vagus stimulation, were done in which observations were made, first on the volume of the kidney by means of the oncometer, and secondly, on the blood-flow from the kidney by actual measurement."

"In no case did I find the slightest change in the kidney volume as shown by the oncometer during vagus stimulation."

The loss of function of one kidney by disease or by nephrectomy is followed by no derangement of the process of urinary secretion. If the remaining kidney is sound it is abundantly able to carry on the entire process. It is usual, however, to find a compensating hypertrophy of the remaining organ which is due to an increase in the size of the glomeruli and of the convoluted tubules or to an increase in their number if the condition is congenital. The amount of hypertrophy

varies and the enlarged kidney may even exceed two single kidneys in its dimensions (Moore, *loc. cit.*). Such an increase in size sometimes gives rise to painful pressure symptoms and may be the first indication of renal disease. In such cases the location of the pain will often be misleading as the true renal lesion which has brought about the compensating hypertrophy is on the opposite side. On account of its increased size the hypertrophied kidney may be more readily palpated than its fellow and for this reason also doubt may arise as to which kidney is diseased. Such problems are usually solved by an examination of the urinary output of each kidney by means of ureteral catheterization and a functional test of each organ. For most conditions involving the surgery of the kidneys the permeative test with phenolsulphonephthalein is now considered most reliable and satisfactory. A method of estimating renal sufficiency by measuring the amount of diastatic ferment in the urine from each kidney has been recently receiving attention and may come into use. Wohlgemuth (Ztschr. f. Urol., 1911, v, 801) claims that diseases of the kidney produce alterations in the amount of diastase, a fact which serves as a useful indication of the functional capacity of the kidney.

TUMORS OF THE KIDNEY

As compared with tumors of many other parts of the body, tumors of the kidney are relatively infrequent. "From the early eighties to the present time the clinical records of the Massachusetts General Hospital contain only 74 cases proved by operation or autopsy. This series does not, however, include many neoplasms of the kidney accidentally discovered at the autopsy table and which gave no hint of their presence during life" (Barney, Symptomatology of Renal Tumors, Boston M. & S. J. 1913, clxviii, 300–302).

The operative records of St. Mary's Hospital, Rochester, Minn., to July 1, 1912, include but 83 cases of malignant tumors of the kidney (Braasch, Clinical Data on Malignant Renal Tumors, J. Am. M. Ass., 1913, lx, 274–278).

A study of the Hospital Reports of St. Bartholomew's (London) 1908 to 1912 inc.; Bellevue, New York City, 1908–1909–1911–1912; St. Mary's, Rochester, Minn., 1908–1909–1911–1912; Lakeside, Cleveland, Ohio, since 1890, shows that among cases treated at these hospitals, renal tumors constituted but 14 per cent. of all the tumors of the urogenital tract.

Solid renal tumors occur most frequently at two periods of life—in early childhood and after forty. Those of most frequent occurrence are hypernephroma, carcinoma and sarcoma.

Clinically, the classification of solid renal tumors is extremely difficult—the histological classification, even, is not yet finally standardized.

Hypernephroma.—Hypernephromata constitute more than 80 per cent. of all solid renal tumors, some authors even contending that 90 per cent. of tumors after the age of puberty are hypernephroma. Opinions vary as to the origin and exact nature of these growths. Wilson (Ann. Surg., 1913, lvii, 522), after a considerable experience with this type of tumor, maintains that they originate from the remains of the wolffian bodies; while Grawitz and his followers attribute their origin to aberrant adrenal tissue.

In general, observers agree that hypernephromata are malignant, although they seem to be benign in the beginning of their development. Metastases most frequently occur in the long bones, in the bones of the skull, sternum or pelvis, in the lungs and in the liver—a fact which must always be considered in making the diagnosis and in giving a prognosis. Hypernephromata occur practically always after middle life.

Carcinoma.—Renal carcinoma is relatively infrequent; Swan (Lancet, 1913, i, 374) states that it constitutes no more than 2 per cent. of all renal growths. Renal carcinomata are gray, yellowish or reddish brown on section. The renal pelvis is frequently invaded and the growth may extend even to the ureter and bladder. A characteristic feature of this type of renal tumor is the gradual softening and breaking down of the capsule. Renal carcinomata usually result fatally in their early stages and therefore as a rule do not become very large.

Sarcoma.—Renal sarcomata are softer tumors than carcinomata, are frequently nodular, and appear grayish on section. Sarcoma occurs in the kidney as a primary tumor in both the round and the spindle-cell variety. Although numerous cases are reported in adults, it is more frequently found in children. Unlike carcinomata, sarcomata often grow very large before destroying life.

Adenoma.—Adenomata are found in the kidney in both the benign and malignant forms. They may at first be benign and after several months show signs of malignancy, and for this reason some pathologists believe that the benign and malignant types are identical and differ only clinically. Various transitional types occur also. Squier (Tr.

Am. Ass. Genito-Urin. Surg., 1911, vi, 169–173) tells us that among 529 renal growths, Albarran and Imbert found only 13 malignant adenomata and that Eisenstadt, in addition to one case of his own, after a careful search of the literature, found only one adenoma which was absolutely proven to be malignant, that of Sudeck, 1892. Renal adenomata appear in three forms, the tubular, alveolar and papillary, the last being the most frequent.

In a malignant adenoma all the characteristics of carcinoma may appear.

Angioma.—Angioma of the kidney is of very rare occurrence. Swan (*loc. cit.*) says of it: "Recently a form of angioma of the apex of the renal papilla giving rise to renal hematuria has been described by Hurry Fenwick, but a more rare condition in which cavernous angioma existed in the kidney as a distinct tumor came under my care in November, 1911."

Lipoma and fibroma are seldom found and are unimportant.

Embryonic Tumor.—There are three main types of embryonic renal tumors:

1. Dermoid growths, sometimes called teratomata.
2. Rhabdomyomata.
3. Mixed tumors.

A teratoma which faithfully reproduces fœtal parts must be regarded as a fœtal inclusion. Such a growth is explained in various ways. It is probable that it is a result of some accident to the ovum in its early segmentation; or it may be a consequence of faulty fissions in a young embryo, as a result of which certain parts grow in abnormal positions.

There is no uniformity of opinion as to the origin of embryonic tumors. Swan (*loc. cit.*) states that Wilms suggested that the various elements of mixed tumors arose from islets of embryonic tissue. Their structure is very complex but one variety of tissue predominates as a rule.

That renal dermoids are of exceedingly rare occurrence is shown by the fact that only a small number of cases have been reported (Baldwin, Surg., Gynec. & Obst., 1915, xx, 219).

Mixed tumors of the kidney contain both carcinomatous and sarcomatous elements and for this reason they have been variously designated by different authors, Birch-Hirschfeld (Watson and Cunningham, G. U. Diseases, 1908, II, 212) being the first to put them in a class by themselves.

Watson and Cunningham have collected the various views regarding their pathogenesis and quote these:

1. The wolffian body.
2. The embryonic kidney.
3. The aberrant cells of the myotone or other similar structures.

Mixed tumors are grayish white or yellow on section, grow very rapidly and often become quite large. Watson and Cunningham (*loc. cit.*) state they may reach the weight of even 10, 12 or 14 pounds. Since pain is not a prominent symptom of their presence, the patient may not be aware of the growth until he notices the enlargement. Metastases are rare.

Symptoms.—Of the three cardinal symptoms of solid renal neoplasms, hematuria, pain and tumor, the first is by far the most important. The patient may complain of all three of these symptoms or of any combination of two and in rare instances of only one. Hematuria is noted in about 70 per cent. of the cases; in the majority of cases it is painless and is accidentally discovered at first. It is often very profuse and is generally intermittent, but if unaccompanied by pain little attention is paid to it as a rule, for it is accepted as one of those accidental conditions which may occur without any special significance. Because of this negligence on the part of the patient and perhaps of the physician also, many of these growths are unrecognized until they have developed to a considerable size, or until after repeated attacks of pain it occurs to both patient and physician that something is radically wrong in the region of the kidney. All cases of renal hematuria should be submitted to a most rigid examination in order to prove or disprove the presence of a neoplasm. Blood in the urine is always a pathological condition and must be so recognized, even if the cause producing it is not a serious one. For a considerable length of time it is often the only symptom of the presence of a new growth. When hematuria occurs in persons past middle life or in very young children the presence of a growth in the kidney is strongly indicated. Tumors in children can usually be palpated readily, for a sarcoma—the form of renal tumor most frequently occurring in children—grows very rapidly, so that generally by the time it presents any symptoms at all, it is large enough to be easily detected.

Pain is nearly always present at some time during the development of a renal tumor. Occasionally the first symptoms may be renal colic caused by ureteral obstruction from a particle of tissue or blood clot. Severe renal colic or a general soreness on pressure is of secondary

significance as a diagnostic symptom in renal tumor, as either may be due to some other cause. A renal tumor may cause pain, however, either by its pressure on the surrounding structures or by causing increased intrarenal tension as a result of its interference with urinary drainage. Unfortunately the patient rarely seeks aid because of the pain from pressure, before the tumor has grown large enough to press upon the adjacent structures.

The presence of a solid tumor in the region of the kidney, accompanied by hematuria in children or in adults past middle life, is strong evidence of a renal neoplasm. Most abdominal tumors in children are renal sarcomata, which as a rule are not painful upon pressure and manipulation. An X-ray picture will often determine whether a tumor is renal. Not infrequently the tumor mass is the first symptom, and patients consult the physician because they have detected a swelling and not because they have suffered special discomfort from the presence of the tumor or have noted any impairment in their general health. However, in many cases of malignant renal growths patients have been in generally failing health for a considerable time before any local manifestation was evident. Loss of weight is frequently one of the early symptoms.

Diagnosis.—The diagnosis is generally made from the presence of a tumor in the region of the kidney in very young children or in persons past middle life, particularly in men, especially if the tumor is accompanied by hematuria. The possibility of an inflammatory condition in this region can generally be eliminated as inflammation is manifested by fever, often by chills and generally by pus in the urine, symptoms which as a rule are not presented by malignant tumors. An X-ray examination will aid in the differential diagnosis, especially if an injection of an opaque substance is made.

Treatment.—As most solid tumors of the kidney are malignant they should without exception be removed regardless of their histologic structure, provided that the diagnosis has not been made too late. The benign solid tumors are so rare that they need not even be considered. The method and extent of removal will depend upon the size of the growth. As a rule all tumors can be removed extraperitoneally through an oblique lumbar incision extending from the border of the twelfth rib obliquely downward and inward above the crest of the ilium. The incision must be so large that any manipulation can be easily made without dragging too much upon the growth. Muscles are cut. The ilio-inguinal and iliohypogastric nerves must be preserved if possible

and retracted outward. The fatty capsule should not be separated from the kidney, but should be removed intact with the kidney. This oftentimes necessitates a rather extensive dissection, but the only hope of a permanent cure lies in complete removal.

The glands lying in the region of the large abdominal vessels should be removed if possible, especially if they are involved. The renal vein as well as the vena cava should be carefully palpated for thrombi, and if a thrombus be present it should if possible be removed with the tumor mass. If the adhesions are very firm there will probably be considerable bleeding, as these growths are very vascular. The renal vessels should be clamped if possible before beginning the removal of the growth, so that the manipulations may not force any tissue into the veins.

If the tumor be very large, an abdominal incision should first be made, to determine whether or not the glands are involved, or whether there are thrombi in the vessels. Occasionally the best method of beginning the removal is to ligate the vessels through an abdominal incision after closure of which the retroperitoneal incision is made, the growth dissected by beginning at the pedicle and working outward.

The removal of a large kidney tumor will oftentimes necessitate the removal of the adrenal as well, but the sacrifice of one adrenal will not make any difference as long as the other one is intact.

It is occasionally difficult to ligate the vessels securely and many operators advise leaving the clamps on for several days and then removing them gradually. This has never seemed a safe procedure to the author, who for sometime has used the pedicle clamp which is shown in the cut (Fig. 140). By the aid of this clamp the pedicle can be sewed off, thus preventing any possibility of slipping. This procedure has proved most satisfactory. Smaller forceps of the same type might be used in the section of part of the wall of the vena cava in cases in which the vessels are involved, the wall of the vein being sutured by a very fine needle and silk. The use of hot gauze packs in the cavity for a short time will generally stop all oozing. All vessels of any size should be ligated. Drainage as a rule is not necessary and should not be employed.

The ureter is simply tied off with a catgut ligature and is either divided by the actual cautery or by the scalpel, the cut edge in the latter case being cauterized with carbolic acid. In the inoperable cases considerable diminution of the tumor and great relief has followed the application of the X-ray, but few if any permanent cures

FIG. 140.—Kidney clamp.

have been reported. In cases of recurrent growths the X-ray is beneficial and should always be applied.

Prognosis.—The prognosis in any case of renal tumor is grave, as the danger of recurrence is very great. In a great majority of cases the tumor is recognized too late for a complete removal to be possible, and for this reason there is recurrence in more than 90 per cent. of the cases.

If we are to lessen the percentage of recurrences, these tumors must be diagnosed earlier, when it is still possible to remove them completely. With renal as with breast tumors the physician must not wait to see whether the case is malignant before advising the removal of the growth, for when malignancy is definitely recognized it is already too late to hope for a final cure.

The immediate operative mortality rate has been too high, for under present methods there should be no deaths from shock.

If there be much hemorrhage at the time of operation, or if the patient shows the effect of pre-operative hematuria, then a blood transfusion is indicated, either before or at the time of the operation. All manipulations during the operation should be made with the greatest possible gentleness.

It is well to note also that a single metastatic growth need not necessarily preclude an operation—for if accessible it also can be removed and a second metastasis may not occur.

Tumors of the Renal Pelvis.—Tumors originating in the pelvis of the kidney are rare. As I have stated previously (Surg., Gynec. & Obst., 1914, xviii, 151), Watson and Cunningham report that Israel found only two cases of tumors in the kidney pelvis as compared with 68 in the kidney parenchyma, and that there was but one tumor (a papilloma) among 94 cases of renal and perirenal growths recorded at the Massachusetts General and Boston City Hospitals in 10 years. In 1904 Albarran and Imbert in their book "Traité des Tumeurs du Rein" found only six instances in all of the literature on the subject. Stüsser in 1912 reported a considerable number of tumors in the renal pelvis and a small number in which the ureter and bladder were also involved. They are classified as follows: papilloma, papillary epithelioma, epithelioma and sarcoma. No definite theory is advanced for the cause of these neoplasms. Albarran and Imbert found that in 15 per cent. of their cases calculi were present, and concluded that they had produced chronic irritation and thus favored the development of neoplasms.

They usually occur between the ages of 40 and 60 years and are more frequently found in men.

As for the symptoms, they are quite variable and depend as a rule upon the stage of development. Hemorrhage, tumor, pain, and epithelial elements in the urine generally indicate that a growth is present. The first sign is usually hemorrhage. It may be continuous, or intermittent, and occasionally cases are noted in which it is entirely absent. It may also vary in amount, at times being scarcely noticeable and then again so profuse as to cause death. Pain is not a constant symptom nor an important one; it may come on in attacks of colic, unexpectedly, and occasionally there is merely a sensation of numbness in either the opposite leg or in the loin and leg of the same side. Hartmann reports a case of a man, 51 years old, who had suffered almost continuously with renal pains since his twentieth year. Another instance of a long duration of renal colic is Oraison's case. This was a woman, 50 years old (at the time of the report), who complained of violent renal colic from her twenty-second to her fortieth years. The pain occurred at intervals of one to three days and as a rule was followed by hematuria lasting several days. After she was 40 the pains were less severe but continuous.

There are also some general symptoms to be noted, such as weakness, marked pallor, loss of flesh, anæmia and loss of appetite. Fenwick has called attention to an important sign, namely, that when there is a growth in the pelvis of the kidney in which there is pelvic dilatation, there is a dull-colored swelling at the ureteral orifice and an elongation of its opening. The growths may originate in the pelvis and spread to the ureter, or *vice versa*.

It is very often hard to determine just where the growth is located, but with the aid of the cystoscope and by ureteral catheterization and injection of collargol one may make a fairly accurate diagnosis. A tumor at the ureteral orifice may be a transplantation and should lead one to suspect a growth higher up. It is not unlikely that in a certain number of recurrent tumors of the bladder, situated in proximity to a ureteral orifice, the real source of the trouble may be a growth in the ureter or kidney pelvis, the recurrences being transplantations. Evidences of renal pelvis papilloma may be present in a benign form for a long time, for months or even years, and the general health may suffer but slightly. Sooner or later, however, symptoms of malignancy will appear. Early removal of the kidney, and in most cases of the ureter as well, is the only treatment.

Tumors of the Ureter.—Even more rare than tumors of the renal pelvis are primary tumors of the ureter. Suter (Urol. and Cutan. Rev. Tech. Sup., 1913, i, 62) has recently reviewed the literature on this subject and found only eight cases. He reports an interesting case, in which the prominent symptom was hematuria, which was so severe that he was compelled to perform one operation after another—cystotomy, nephrotomy, nephrectomy and finally ureterectomy. At the last operation a solitary benign papilloma was found to be the real cause of the hemorrhages.

He observes that it is quite unusual to find a single papilloma. The symptom of hydronephrosis, the regular consequence of a tumor of the ureter, was entirely absent. Because the existence of a ureter papilloma was entirely unsuspected, the diagnosis was rather complicated but, as Suter suggests, this could largely be eliminated if, by means of the ureteral catheter, one could perceive that the urine from the upper sections of the ureter came away free of blood, and that the admixture of blood had its origin in the lower part of the ureter; by doing this the kidney might be saved. Whether a definite diagnosis of ureteral tumor can be made without an exploratory operation is extremely doubtful. If a tumor can be demonstrated, the only treatment is resection of the ureter and either an anastomosis or transplantation of the ureter. If neither can be successfully accomplished, a nephrectomy should be done.

CYSTS OF THE KIDNEYS

Cysts of various kinds are encountered among the pathological lesions which affect the kidneys. They may be briefly classified as follows:

I. Retention cysts resulting from other lesions of the kidneys.
II. Solitary cysts.
III. Polycystic degeneration, or polycystic disease of the kidneys.
IV. Cysts of parasitic origin (echinococcus).
V. Dermoid cysts.

Retention Cysts.—Perhaps the most familiar renal cystomata are the retention cysts, caused by chronic inflammatory changes, which are seen in some cases of chronic interstitial nephritis. It is not unusual to find them also in connection with other lesions of the kidney which cause obstruction or constriction of the urinary tubules or of the lymph channels. In this manner, neoplasms and calculi may lead to

cyst formation; and when these cysts attain any considerable size they encroach upon the renal parenchyma and cause still further degenerative changes. When located near the surface of the kidney the form of the organ may be altered by the outward distention of the cyst walls beneath the fibrous capsule of the kidney. In a majority of cases retention cysts, which result from inflammatory changes or from other conditions such as those just mentioned, are few in number, of small size, and of no surgical importance in themselves, but they may at times complicate the renal disease which brings about their formation, especially when they produce pain by tension upon the fibrous capsule of the kidney or when, by becoming infected, they lead to abscess formation.

Solitary Cysts.—In a few instances solitary cysts have been encountered in otherwise normal kidneys. Such cysts seldom reach sufficient size to require surgical intervention. Von Brackel (Vogel, Zentralbl. f. Chir., 1912, xxxix, 1540–1544) in 1899 found only 21 cases reported in the literature, and Tuffier in 1902 collected reports of 38 cases. In most cases but one kidney, usually the left, is affected and the cyst is located in the region of the lower pole. The majority of the reported cases have occurred in females, and v. Brackel believes that tight lacing predisposes to the formation of such renal cystomata. The author has had one case of a woman who had a solitary cyst about the size of a hen's egg at the upper pole of the left kidney. She had had considerable and pain soreness, to determine the cause of which an exploratory incision was made. The cyst was shelled out intact and quite easily, with very little hemorrhage. In the ten years which have passed since the operation there has been no recurrence of symptoms. Other writers believe that solitary cysts are of congenital origin and that they result from isolated arrests in the development of the kidney (Vogel, *loc. cit.*).

All cysts of the kidney, whatever their origin, are subject to bacterial infection. Sieber (Vogel, *loc. cit.*) in 1905 reported a series of 200 cases of cysts of the kidney originating from various causes, 10 per cent. of which were infected.

If solitary cysts of the kidney are large enough to cause pressure, they give rise to painful symptoms which may simulate all the stages of renal colic, from very mild to severe attacks. When infection occurs in a cyst which is not entirely shut off from the urinary tubules, the urine may show the presence of pus or microörganisms. Cases have been recorded in which a fluctuant tumor has been noted on abdominal

palpation, but solitary cysts usually do not reach sufficient size to become palpable. The solitary cyst shown in the cut (Fig. 141) was found post-mortem and sent to the author by Dr. F. P. Anzinger of Springfield, O.

Treatment.—The resection of a solitary cyst can usually be accomplished without much difficulty. Occasionally the resection of

FIG. 141.—Solitary cyst of kidney found post mortem and forwarded to author, by Dr. F. P. Anzinger.

part of the kidney may be necessary, but complete nephrectomy is rarely required.

Polycystic Degeneration.—A much more distinctive type of cyst formation in the kidneys is that known as polycystic degeneration, or polycystic disease of the kidneys. This condition is bilateral in the

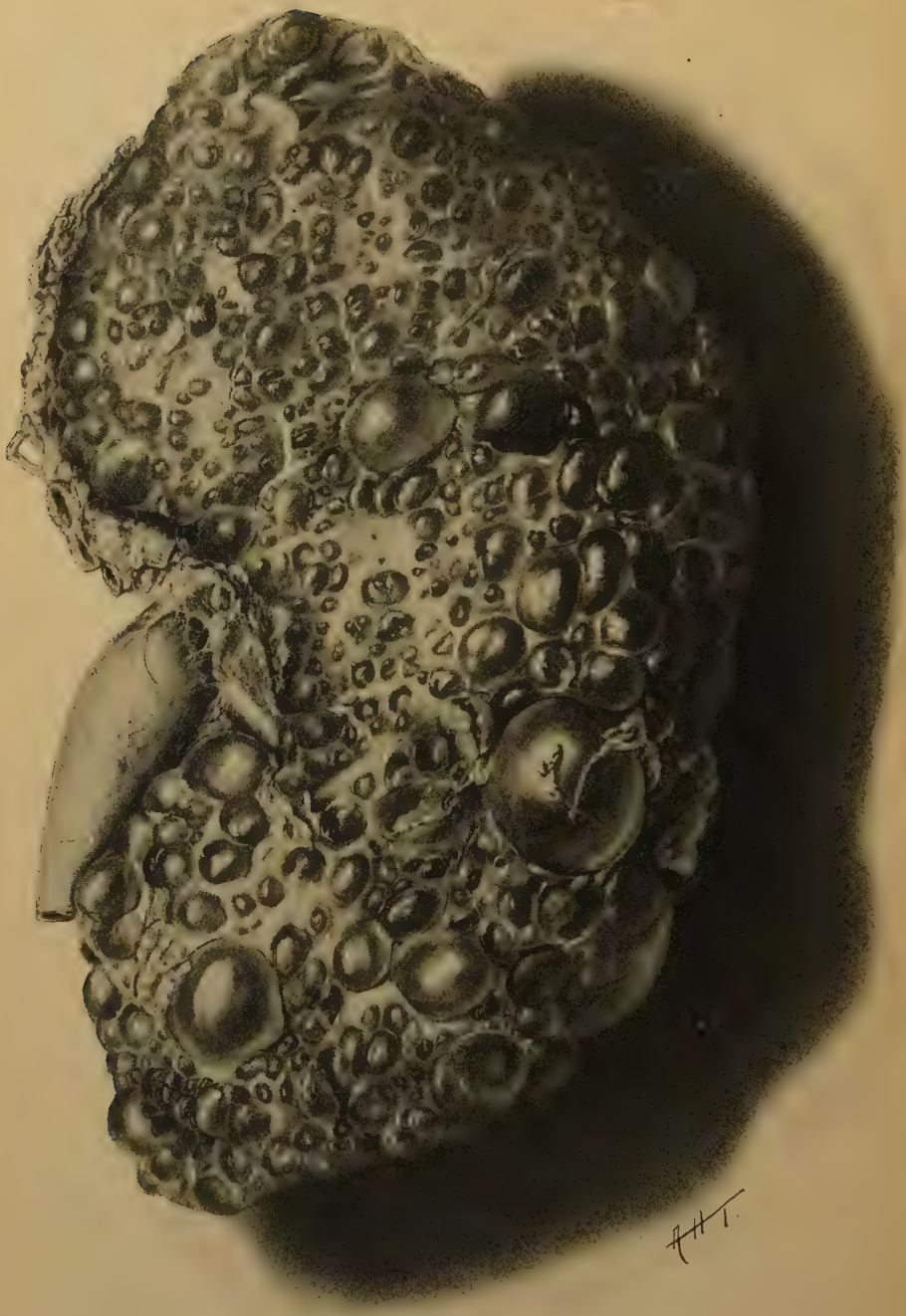

FIG. 142.—Polycystic kidney.

great majority of cases, and is characterized by the formation of numerous cysts throughout the parenchymatous portion of the kidneys.

Kidneys showing the changes of polycystic degeneration are very interesting pathological specimens (see cut, Fig. 142). Such kidneys are usually very much enlarged, often becoming three or four times the size of the normal organ. The weight is proportionately increased, sometimes reaching 3 or 4 pounds. All through the renal parenchyma are scattered multiple cysts which vary greatly in size, and often in color, according to their contents. The average diameter of these cysts is about 1 cm., but some may be microscopic while others are as large as a hen's egg. When closely adjacent, the thin walls of adjoining cysts may fuse so that they form multilocular structures. The general arrangement of the cysts in the substance of the kidney is in clusters not unlike bunches of grapes, with kidney tissue surrounding them. The cysts give to the surface of the kidney an irregular lobulated appearance, the color of their contents—yellow, red or green—being transmitted through the thin cyst walls. This variety in color adds to the pathological picture. The cystic contents are liquid or colloidal in character, and ordinarily are derived from the urine except when bleeding occurs within the cysts. Urinary constituents such as hippuric acid, calcium oxalate, cystin, leucin and tyrosin can usually be demonstrated. Albumin is commonly found, and if bleeding has occurred hemoglobin or its derivatives are present (Torrance, Am. J. Obst., 1913, lxvii, 736–740).

Up to the present time no entirely satisfactory explanation of the origin of polycystic degeneration of the kidneys has been furnished. Virchow offered the theory that the multiple cysts which occur in this condition are the result of inflammatory conditions which serve to occlude the urinary tubules thus causing the retention of their contents. This theory is not generally accepted at the present day, opinions regarding the origin of polycystic kidney being now about equally divided between those who consider it the result of a congenital arrest of development and those who regard it as a species of neoplasm, while some consider the disease to be a combination of congenital arrest of development with neoplastic formation. Rovsing (Am. J. Urol., 1912, viii, 120–124) summarizes the principal arguments for the congenital origin of multiple cysts of the kidney, chief among which are the rather frequent occurrence of polycystic kidneys in the last half of uterine life or in very young infants, and the fact that numerous cases have been reported in which several members of one family have

been affected with kidneys containing multiple cysts. In support of the neoplastic origin may be mentioned the occasional occurrence of multiple cysts in both the liver and the kidney, in which cases the cysts of the liver have been considered to be of metastatic origin (Senator, Nothnagel's System of Medicine, Kidney and Spleen), and Rovsing (*loc. cit.*) considers the usual coexistence of the cysts in both kidneys as further evidence that they are neoplasms.

Perhaps the best supported theory regarding the origin of polycystic degeneration of the kidneys, however, is that which ascribes their origin to congenital arrest of development. This theory is based on the fact that the urinary tubules of the kidney develop from two separate anlagen. The secretory tubules and glomeruli develop independently of the excretory tubules and the renal pelvis, the latter structures being derived from the upper portion of the ureteral duct. As the development of the normal kidney proceeds, the secretory tubules anastomose with the excretory structures before the organ assumes its urinary function, and through the channel thus formed the urine passes from the kidney to the renal pelvis and thence through the ureter to the bladder. When anastomosis of the secretory apparatus of the kidney with the excretory structures fails to occur during the course of kidney development, the secretion of urine within the glomeruli and secretory tubules may go on for a sufficient length of time to cause their dilatation and subsequent degeneration to cyst formation. Under these conditions polycystic disease of the kidney would obviously be due to the arrest of development, and it is a noteworthy fact that in numerous reported cases other malformations have coexisted, such as anencephaly, talipes, spina bifida, atresia of the prepuce, imperforate anus, absence of the bladder, occlusion of the ureters, cleft palate, polydactylism, absence of limbs, etc. (Senator, *loc. cit.*). Hornowski (Virchow's Archiv f. path. Anat., etc., 1912, ccvii, 61–65) has made a study of polycystic kidneys by injecting carmine into the cysts under low pressure, with subsequent dissection and microscopic examination, and he concludes that the cysts arise as a consequence of the non-union of the tubules and kidney pelvis. The increase of fibrous tissue in the renal parenchyma surrounding the cysts, which has sometimes been noted, is considered by this investigator to be only a part of the disturbance in development, and not a formation of renal fibromata in the true sense of the word. As has already been stated, polycystic kidneys are often congenital in origin as they have been found in fetuses during the second half of

uterine life and in mature infants immediately after birth. Owing to the extreme abdominal enlargement of a child so affected the condition may complicate labor, giving rise to fœtal dystocia. Williams (Textbook on Obstetrics, 1912, 820) mentions a case delivered by him and described by Lynch (Surg., Gynec. Obst., 1906, iii, 628–637), and gives an analysis of 50 other cases reported in the literature.

While many cases of polycystic kidneys have been reported in infants, Garceau (Rischbieth and De Crespigny, Lancet, 1913, i, 450–453) and Senator (Nothnagel, *loc. cit.*) both consider the disease to be more common to middle life. Sieber (Rischbieth and De Crespigny, *loc. cit.*) gives the age incidence of 173 cases as follows:

Between 30 and 40 years	26 cases.
Between 40 and 50 years	22 cases.
Between 50 and 60 years	67 cases.
Between 60 and 70 years	40 cases.
Between 70 and 80 years	10 cases.
Between 80 and 90 years	6 cases.
Between 90 and 100 years	2 cases.

It is noteworthy that very few cases occur between infant life and the third decade. Such a long quiescence has led some writers to believe that the cases occurring in middle life are not congenital but acquired. Morris (Surgical Diseases of the Kidney and Ureter, 1901, i, 633) takes this point of view.

Apparently sex has little bearing upon the condition. Sieber (Rischbieth and De Crespigny, *loc. cit.*) found that in a series of 198 cases, in which the sex was stated, 116 occurred in the female.

The presence of more than one case of polycystic kidney in the same family is sufficient to aid the diagnosis should others in the same family present symptoms of some kidney affection. The author has recently been consulted by a young man whose grandmother died of some kidney trouble; his mother and aunt died of double cystic kidneys; the daughter of the latter (his cousin) has double polycystic kidneys; his uncle died of Bright's disease; and his daughter (patient's cousin) died of polycystic kidney—a total on his mother's side of four cases of double polycystic kidneys, three of which have already resulted fatally.

Ninety-eight per cent. of all cases are bilateral, but the left kidney seems to show more involvement than the right, and in the few cases of unilateral polycystic kidney reported, the left kidney has been more frequently the affected organ (Torrance, *loc. cit.*).

Prognosis.—Cases which occur in infants are usually promptly fatal, death being the result of renal insufficiency or of some associated ab-

normality such as imperforate anus (Osler, Modern Medicine, 1909, vi, 193). When the disease does not develop sufficiently to cause symptoms before adult life the prognosis is more favorable. As has already been stated, cases of polycystic kidney have been recorded in patients over 90 years of age (Sieber, Rischbieth and De Crespigny, *loc. cit.*).

In adult life the clinical picture of the disease resembles in many ways that of a neoplasm of the kidneys. The disease does not encroach rapidly upon the renal tissue as do malignant tumors, but the cystic degeneration progresses slowly and encroaches by pressure upon the renal parenchyma, which as a result atrophies until symptoms of renal insufficiency appear. Uremia is a late symptom of polycystic disease of the kidneys, but this may not develop for years—in fact for a long period of time the general condition of the patient may remain undisturbed by the presence of the disease. In the rare instances in which but one kidney is affected there may be no symptoms whatever during life, death occurring from other causes.

Symptoms.—In most cases, one of the leading symptoms of polycystic disease of the kidneys is pain in the renal region. Pain is not a constant symptom, however, and in some cases no symptoms are apparent before the onset of uremia. When pain is present, it may vary from a mere sense of pressure to the severe cramps of renal colic, which begin in the lumbar or abdominal region, may be unilateral or bilateral, and tend to radiate downward to the iliac region and even into the lower limbs. The pain is intermittent in character and by reflex action may involve the testis as in cases of stone in the kidney or ureter.

Hematuria, recurring at intervals for years, is perhaps more characteristic of the disease than is pain (Witherspoon, J. Am. M. Ass., 1910, lv, 1453). This symptom may demand relief before the final uremic stage develops. The amount of hemorrhage varies and alternating attacks may occur, the blood coming first from one kidney and then from the other.

Changes in the urine may be present or absent. As the disease advances and the destruction of renal tissue increases, the urine is similar to that in chronic interstitial nephritis, and the other general symptoms of renal insufficiency are present. At this stage the urine is of low specific gravity, and contains albumin and hyaline and granular casts (Osler, *loc. cit.*). The complexion becomes pale and muddy, with bronzed skin in rare instances. The cardiovascular complications which accompany chronic nephritis may also be present, such as hypertrophy of the heart with accentuation of the second sounds, and sclerosis of the

arteries. When one or more cysts become infected fever may occur, but otherwise the temperature is not affected.

In the terminal or uremic stage emaciation and loss of strength are common, with headache of increasingly frequent occurrence, dyspnœa, drowsiness, convulsions, and coma.

If the kidneys are sufficiently increased in size the condition may be discovered by abdominal palpation. The author now (December,

FIG 143.—Showing outline of bilateral cysts of kidneys.

1914) has under observation a robust looking young man about 30 years of age, who consulted him because of hematuria. Cystoscopy showed blood coming from the right ureteral orifice. Abdominal palpation revealed a large tumor on each side extending up into the groins—undoubtedly double polycystic kidneys. Up to this time he has suffered no inconvenience from the presence of the tumors or from the condition of the kidneys, excepting the occasional hematuria. He is

very active and has a good color. The cut shows the outline of the tumors (Fig. 143).

Diagnosis.—The diagnosis of polycystic degeneration of the kidneys is very difficult. Since 98 per cent. of all cases are bilateral, one should hesitate before making a positive diagnosis in the absence of symptoms which clearly indicate a lesion of both kidneys. Since the polycystic degeneration impairs renal function, an accurate diagnosis of the condition is essential to prevent surgical intervention for other lesions which would decrease the already impaired efficiency of the kidneys. Before undertaking any renal operation which necessitates the functional or anatomical loss of renal parenchyma, therefore, the efficiency of each kidney should be determined by the analysis of specimens of urine obtained by ureteral catheterization, and by means of functional tests.

The most reliable evidence of the presence of cystic kidneys is the presence of bilateral masses in the upper abdominal cavity in the location of the kidneys, especially if these tumor masses are fluctuant on palpation, with irregular prominences on their surfaces.

The presence of hematuria has little diagnostic value since it occurs in so many other lesions of the urinary tract. If the hemorrhages are intermittent, however, and their occurrence continues over a long period, and if it can be conclusively shown that both kidneys are involved, the presence of polycystic degeneration may be strongly suspected.

Pain, if unaccompanied by other symptoms, can rarely be relied upon for absolute diagnosis; in fact, it frequently complicates the situation as it often simulates the pain of ureteral obstruction. When the pain is bilateral, however, in the region of both kidneys and of an intermittent character, it serves as a valuable aid to diagnosis when combined with the presence of the bilateral tumor masses already mentioned.

Senator (*loc. cit.*) has stated that the presence of rosettes of leucin-like bodies in the urine furnishes valuable evidence of the presence of polycystic degeneration. By no means the least important clue to diagnosis is a family or hereditary predisposition to kidney disease.

In all suspected cases a cystoscopic examination is indicated and a chemical and microscopical analysis of urine obtained from each kidney by ureteral catheterization. Such a procedure will often give the first indication that a bilateral lesion is present, and will suggest

the presence of polycystic degeneration, but it must be borne in mind that the urinary constituents of this condition vary greatly.

Treatment.—No curative measure has as yet been devised for double polycystic kidneys. Rovsing (*loc. cit.*) advises multiple puncture for the relief of the symptoms and those who have tried this procedure have found it beneficial. The cysts are punctured, and if no infection is present, no drainage is employed. If the cysts are infected, drainage is installed for as long as may seem necessary.

For unilateral polycystic kidney, nephrectomy should be performed. The author has one case in which the presence of hemorrhage and infection demanded operation. After the kidney was exposed, the condition proved to be infected polycystic degeneration. Nephrectomy was performed eight years ago there has been no return of symptoms, and the patient has remained in good health.

Albarran and Imbert report 34 nephrectomies with 25 recoveries of which 14 were traced, two for seven years, one for six years, four for three years, three for two years, and four for one year.

Sieber (*loc. cit.*) reports 62 nephrectomies of which 20 died soon after the operation, while others were traced, two for seven years, one for six years, one for five years, four for three years, two for two and one-half years, and the balance from 5 to 14 months.

Parasitic Cysts (*echinococcus*).—According to Casper (Genito-Urinary Diseases, 1909, 544) the kidney more frequently than the liver is attacked by the tænia echinococcus. Such cases are extremely rare in this country and when they do occur usually are found among those of foreign birth. While it may be possible to recognize the presence of echinococcus cysts when a fluctuant renal tumor is detected on palpation, the most reliable means of diagnosis is the presence in the urine of the characteristic vesicles and hooklets, the result of the rupture of some of the cysts into the pelvis of the kidney. Pus and blood may also be present as a result of secondary changes, and the urine has a white milky appearance. Casper (*loc. cit.*) gives the warning, however, that the presence of echinococcus cysts in the urine does not necessarily mean that they came from the kidney, for the primary cyst may have been in the liver from which location it perforated the renal pelvis, or a cyst between the rectum and bladder may have broken into the latter viscus.

The prognosis may be considered favorable. The disease may go on for years without giving rise to trouble. The passage of cysts along the ureter may sometimes give rise to transient colicky pains. It is

of course true, however, that as the cysts increase, pressure will cause the renal parenchyma to become atrophic.

Treatment.—Evacuation of the cysts and the application of tincture of iodine and iodide of potash internally is probably the most efficient means of treatment.

Dermoid Cysts.—The occurrence of dermoid cysts in the kidney is so rare as to require no discussion.

RENAL AND URETERAL CALCULI

Renal Calculus.—Renal calculi are most frequently found between the ages of 20 and 40, though they occasionally occur in the very young and in the aged. They are about twice as frequent in men as in women; are more usual in the obese than in the thin; in those leading sedentary lives than in the physically active; in those addicted to the free use of alcoholic drinks and in those who eat excessive amounts of nitrogenous food than in the temperate.

Kidney stones may vary in number from many very small stones to a single large stone which fills the whole pelvis and the calices, and weighs as much as 1½ pounds, as in a case reported by Watson and Cunningham (Genito-urinary Diseases, 1908, ii, 210).

Most renal calculi have a mixed composition containing oxalates, urates, phosphates, uric acid and occasionally cystin and xanthin.

No definite cause for nephrolithiasis has as yet been discovered though it is generally supposed to be more prevalent in localities in which the drinking water contains a large amount of lime salts this point however has not been definitely proven. Squier (Am. J. Surg., 1913, xxvii, 121) says, "Calculus formation in the kidney must be considered as a symptom, or better, an end-product of some abnormal process taking place or having taken place within the body." Heredity also plays an important part in the causation of nephrolithiasis. A clot of blood or muco-pus may serve as the nucleus upon which the urinary crystals are deposited. As to the influence of parasites and bacteria, there is a great diversity of opinion. According to Guiteras (Urology, 1912, i, 500), "Bilharzia hematobia have been found in the central portion of calculi. Bacteria have been reported in calculi by Gallippe, Doyen and Fullerton, but it has not been generally accepted that they act as nuclei."

Renal calculi are classified by many as primary and secondary. Morris (Surgical Diseases of the Kidney and Ureter, 1900, ii, 44)

defines primary calculi as those composed of certain salts or other urinary ingredients which have been precipitated from the urine and bear no relation to any preceding change in the kidney or to any septic condition of the urinary passages; secondary calculi, he states, occur in kidneys which have been the seat of previous disease; in such cases lime salts are precipitated from the urine as the result of the chemical changes caused by the presence of microörganisms. Calculi at first primary may later develop the characteristics of secondary stones.

A stone may exist in the kidney for many years without causing any symptoms and only be discovered post-mortem. Bruce Clark (Handbook of Surgery of Kidneys, 1911, 114) says that in examining the post-mortem records of St. Bartholomew's Hospital for 25 consecutive years, viz., from 1875 to 1900, 57 cases of kidney stones were found; of these in 44 no mention was made of any symptoms of stone during life. He says, however, that it by no means follows that symptoms might not have existed in any of these cases. As long as the stone remains aseptic and in no way obstructs the renal outlet, there may be no symptoms even though the stone is large. The author has had under observation one case in which an X-ray shadow, undoubtedly caused by a stone, was shown in the upper pole of the kidney and yet at no time had the patient had any symptoms of renal calculus. In an X-ray picture taken one year later the shadow showed that the stone had become somewhat enlarged but still the patient was free from symptoms.

The increasingly frequent reports of renal calculi from various clinics do not mean that nephrolithiasis is becoming more prevalent, but, as is true of many other diseases, more cases are being diagnosed as a result of new diagnostic methods, the X-ray and the ureteral catheter.

Stones are found in both kidneys in 20 or 25 per cent. of the cases, though the estimates of different authors vary from 10 to 50 per cent. (Albarran and Legueu). Whatever estimate is accepted, however, it is certain that calculi occur bilaterally with sufficient frequency to necessitate the complete examination of both kidneys and both ureters in every case in which their presence is suspected.

Symptoms and Diagnosis.—The diagnosis of renal calculi was formerly made upon the presence of renal colic. Renal colic, however, is caused not only by the presence of a stone but by any interference with the urinary outlet from the kidney, such as ureteral strictures, aberrant blood-vessels, kinking of the ureters, etc. In these cases the pain is due to the pressure of the urine in the ureter and the kidney,

and not to the passage of any obstructing body as was formerly supposed. Operations for stone based upon a symptom of renal colic alone, therefore, will be doomed to disappointment in many cases. The symptoms caused by renal calculi in the order of their frequency are albumin, microscopic blood, and pus cells in the urine, renal colic, pain and soreness in the region of the kidney, and disturbance of micturition.

The presence of albumin in quantity, and the absence of casts or other physical signs of nephritis would suggest the possibility of calculus. Microscopic blood has been found in more than 80 per cent. of all cases of renal calculi. Pus cells are found in nearly all cases in which other symptoms are present. Renal colic is present in more than 50 per cent. of the cases; colic which sometimes occurs after violent exercise, especially riding or jumping, strongly suggests the presence of a renal calculus. Renal colic, whatever its cause, generally begins in the back and radiates downward along the course of the ureter toward the bladder.

The testicle on the affected side is frequently retracted. Occasionally the pain may be quite remote from the region of the kidney, as in one case in which there was a very definite pain in the knee and in another in which a burning sensation on the inside of the foot preceded the onset of the renal colic. The pain may closely simulate biliary colic; and in very exceptional cases the pain may be in the side opposite to the kidney containing the stone, the so-called "reno-renal reflex."

It must be remembered also that in a horseshoe kidney calculi may cause pain which is located entirely in the epigastrium. This occurred in one of the author's cases in which there were several calculi in the right pelvis of a horseshoe kidney, while the severe pain was in the epigastrium.

Renal colic is nearly always attended by nausea and vomiting and the pain is sometimes so severe as to cause complete collapse.

Physical examination will often reveal a slight rigidity, and occasionally tenderness on the affected side. Occasionally there is a muscular spasm but when there is no dilatation of the pelvis or hydronephrosis, palpation is generally negative.

The greatest aid in the diagnosis of renal calculus is the X-ray and by this method alone renal calculi can be detected in more than 90 per cent. of the cases. Occasionally, in very stout individuals, a small uric acid stone may be missed by the X-ray. The author has had two

cases in which the X-ray did not reveal the uric acid stone which in each case was passed a few days later. When the calculus is on the right side, a mistaken diagnosis of appendicitis or of gall-stones is not infrequently made and many an inoffensive appendix has been removed when the source of the trouble was a renal calculus. An appendix scar with symptoms still remaining generally means a mistaken diagnosis. If there be no infection or if infection be very slight there is, as a rule, no elevation of temperature.

Treatment.—If renal colic be caused by a calculus, and if it be the first attack and the stone not very large, operative intervention should be delayed for a time to see whether or not the calculus may be passed. Copious draughts of water, large doses of anodyne and immersion in a hot bath will promote the passage of the stone. Watson recommends giving spirits of turpentine, thrice daily, in 10 minim doses in gelatine capsules.

By the aid of the X-ray the progress of the descending stone can be watched from time to time and if it is making progress no harm can result from delay. If the stone remain stationary or fixed at a given point, however, its removal should not be unduly delayed, else severe damage to the kidney may result.

The operative treatment for renal calculi consists of (1) pyelotomy, (2) nephrotomy and (3) nephrectomy.

(1) *Pyelotomy.*—Calculi in the pelvis of the kidney or in the calices near it, can be very easily removed by pyelotomy, which should be the method of choice. Quite large calculi, even, can be removed through an opening in the pelvis of the kidney, and stones lodged in the calices can often be brought down to the incision by the use of a dull flexible curette. If the kidney is not very adherent it should be brought into the wound, turned forward and the incision made in the longitudinal axis of the pelvis. There is little or no danger of hemorrhage. The incision should be closed with a 00 chromic catgut suture or some other absorbable suture material. Any adjacent fat may be placed over the incision to aid in preventing leakage. Even if there be considerable laceration of the pelvis of the kidney, it can as a rule be readily repaired by a plastic procedure. In one of the author's cases only a small fragment of the pelvis remained intact after the removal of a very rough stone from the pelvis; the rough edges of the torn pelvis were trimmed and it was sutured back to the fringe of the kidney. There was leakage for a few days only, complete union resulted and the kidney functionated perfectly afterward as was demonstrated by

the ureteral catheter. If the kidney be very adherent, it is best to remove the stone without bringing the kidney into the wound. This can be done by enlarging the incision and retracting the surrounding structures sufficiently to expose the pelvis. If the stone be fixed in the calices or in an outlying portion of the kidney, however, it may not be feasible to remove it by pyelotomy.

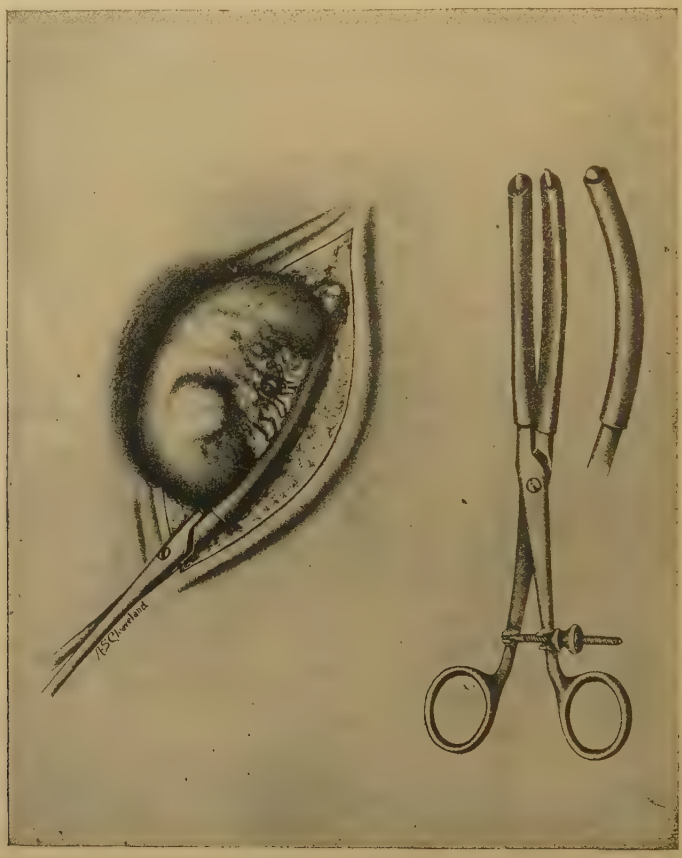

FIG. 144—Clamp for temporary closing renal vessels during nephrotomy.

(2) *Nephrotomy.*—Stones which cannot be removed through the pelvis must be reached by one or more incisions into the kidney, the direction of which will depend upon the location of the stones. If the stone can be reached without complete bisection of the kidney, the best procedure is to cut down directly over it and remove it without cutting any more of the kidney cortex than is absolutely necessary. The objection to nephrotomy is the danger of hemorrhage which is often

quite severe and the possibility also of a consequent persistent urinary fistula. To overcome hemorrhage during the operation, the adjustable rubber covered clamp which is shown in the cut (Fig. 144) has been found most practical. This has been used by the author often enough to prove its merits. The blades can be tightened sufficiently to control the hemorrhage absolutely, and after the stone is removed, the bleeding points can be detected by loosening the thumb screw. These bleeding points should be tied individually, using round curved needles to carry the ligatures. The cut surfaces of the kidney may be then coaptated by mattress sutures which should not be drawn very tightly. Drainage into the kidney should not be established unless there be severe infection. In badly infected cases with multiple stones, nephrectomy should be done if the other kidney is in good functionating condition.

Nephrectomy.—Although nephrectomy has been generally considered a radical operation, yet an examination of the statistics will show that nephrectomy has a lower mortality rate than nephrotomy, as it gives a better protection to the opposite kidney, for prolonged suppuration of one kidney is liable to be damaging to its mate. The exposure of the kidney may be made by a vertical incision extending from a point about two inches from the spinal column downward toward the crest of the ilium. If this does not give sufficient room for delivering the kidney, then the wound may be extended diagonally downward and inward from this point, cutting through the muscles. Or an oblique incision may be made extending from the junction of the twelth rib to the spinal column obliquely downward and inward for a sufficient distance to allow the free delivery of the kidney. The operation should be done retroperitoneally. The ilio-inguinal and iliohypogastric nerves should be carefully avoided, but if they are cut they should be sutured immediately.

If the X-ray shows the calculus in the pelvis of the kidney a sufficient distance below the ribs, a transverse incision through the skin and muscles will make an ample exposure, especially if the side of the body is elevated.

A condition that may easily be mistaken for calculus is incrustation or deposit of calcareous material in the kidney or ureter. Several cases have been reported by Caulk (Surg., Gynec. Obst., 1914, xviii, 497) who discovered the lesion at operation. It has been suggested that necrosis is the prime factor in such formations. The condition can be differentiated from calculus in the following manner:

"(*a*) Faint X-ray shadow.

(*b*) The passage of crushed egg-shell-like material following manipulation with the ureteral catheter.

(*c*) The passage of the catheter through the obstruction, relieving the patient of symptoms, the X-ray shadow still persisting.

(*d*) The gradual disappearance of the shadow, by manipulation with the ureteral catheter."

FIG. 145.—Right ureteral calculus. Tip of calculus presenting through ureter opening.

If there are symptoms which demand operative intervention, he advises nephrotomy, and if the deposit is located in the ureter the method of choice is removal by means of the ureteral catheter.

Ureteral Calculus.—Ureteral calculi rarely develop in the ureter itself but usually originate in the kidney and become lodged in the ureter in their descent from the renal pelvis to the bladder. As is evident, therefore, their composition is the same as that of renal stones. They are most frequently found in the narrowest parts of the ureter, that is, at its renal end, at the pelvic brim and at or near its entrance

into the bladder wall. Not infrequently they are lodged in the vesical portion and may be seen by the cystoscope during expulsive efforts of the ureter as is shown in the cut (Fig. 145).

Originally a ureteral calculus is not very large, certainly not in its early stages, but when it has lodged and remained in one place for a long time it grows by the constant additions of urinary deposits, in some instances reaching the size of a hen's egg. If it remains in the ureter for any length of time, it generally becomes oblong in shape. Ureteral stones usually occur singly, but not infrequently multiple calculi are found. A rare case in which the calculus formed a complete cast of the ureter has been described by Collinson in the Lancet (1913, ii, 1456).

The cast extended from the kidney to the point of entry of the ureter into the vesical wall. A section of the lower calculus showed at its lower end a small uric acid stone which evidently became impacted during the patient's childhood. Above this successive layers of phosphatic material had been deposited from the urine which was able to trickle past the calculus until the ureter was ultimately filled.

The upper stone was rather more than 5 in. in length, and the lower 2½ in. The weight of the first was 840 grains and of the second 440 grains, a total of 1280 grains or 83.2 grams.

Collinson quotes a similar specimen from Morris (Surgical Diseases of Kidney and Ureter, 1910, ii, 450) in which a calculus 5½ in. long occupied the right ureter, almost filling it; but this case was discovered post-mortem.

Symptoms.—The symptoms of ureteral calculi are usually the same as those of renal calculi, that is, severe pain in the back extending downward along the course of the ureter. The pain is undoubtedly caused by the distention of the ureter above the stone and not by the irritation of the stone, or by the spasmodic contractions of the ureter. The onset of pain is generally sudden and often severe, and an anæsthetic may be required for relief. If the obstruction is not complete, there may be only slight discomfort or merely backache; while in exceptional cases the symptoms may be so slight as to be scarcely noticeable. Blood may be present in the urine and in nearly every case red corpuscles will be found by microscopical examination. Nausea and vomiting are nearly always present.

If the stone be located in the lower portion of the ureter, the leading symptom is frequent urination with severe vesical tenesmus.

Diagnosis.—Ureteral calculi cannot be absolutely diagnosed from

subjective symptoms alone, as they may result from any condition which produces an obstruction of the ureter, such as kinking, stricture, etc. The X-ray is the greatest aid to an exact diagnosis in cases of renal or ureteral colic, but this requires an expert röntgenologist, and in a radiograph even, it is not always easy to differentiate the shadows in the lower part of the ureter, for phleboliths, or calcified glands along the course of the ureter may be mistaken for calculi. X-ray catheters, the injection of collargol and stereoscopic pictures will help to clear up the diagnosis. A radiograph, however, may fail to disclose a small calculus in a very obese patient and uric acid stones also may fail to be discovered in this way. In two of the author's cases in which the X-ray findings were negative each passed a calculus a few days later. The wax-tipped catheter of Kelly will occasionally disclose the presence of a stone when it cannot be detected by any other method. Geraghty and Hinman (Surg., Gynec. & Obst., 1915, xx, 515) consider the wax-tipped catheter the most accurate method for locating ureteral calculi. They report that "in 6 out of 35 cases of ureteral calculi (20 per cent.) seen in the last two years, it has located a stone where repeated skiagraphs were uniformly negative." Again they state "in a study of our series of 67 cases in which most careful, and frequently repeated, radiograms were obtained, and only those accepted which were perfect, it is possible to show that radiography missed the stone in 15 cases or 22.4 per cent. In seven of these cases a stone was subsequently passed. In six other cases in which the X-ray was uniformly negative, a wax-tipped catheter gave positive evidence by a scratch of the existence of a calculus, the diagnosis being confirmed in every case by either the subsequent passage of the stone or by its operative removal. In the remaining two cases stone was found on exploration."

Treatment.—In a first attack of ureteral colic resulting from the presence of a stone, it is advisable at first to try non-operative means to see if the stone may be made to pass. Copious draughts of water, the hypodermic injection of morphia and a hot bath are of value and it will be well to note also the progress of the descent of the stone from time to time by means of the X-ray. If the stone remains lodged at one point, surgical intervention should not be too long postponed as delay may result in damage to the kidney or in anuria. The method by which a ureteral calculus may be removed depends on the location of the stone. If it be in the lower portion of the ureter, the injection of sterile olive oil into the ureter by means of the ureteral catheter

occasionally seems to facilitate the passage of the stone. If it be near the ureteral orifice in the bladder, the ureter may be dilated through the operating cystoscope when the stone may be grasped and dislodged. A number of operators, especially Dr. Bransford Lewis, report the removal of a number of stones in this way. Unless this attempt be skillfully made, however, more traumatism may be done by intravesical manipulations than by a clean cut dissection. If the calculus be in the upper portion of the ureter, the oblique or transverse incision used for exposing the kidney will generally be the method of choice. If it be in the middle portion, the McBurney gridiron incision may be sufficient to expose the stone; if not, the wound should be enlarged either upward or downward by dividing the muscles sufficiently to bring the ureter into view. A stone in the extreme lower part of the ureter may be reached by an oblique incision extending downward from the crest of the ilium. The exposure of the ureter should, if possible, be retroperitoneal, although there is no strong objection to opening the peritoneum and palpating for the stone in case it cannot be located readily by the retroperitoneal route. The operative field must at all times be kept free from blood in order that a clear exposure may be made. This is best accomplished by the use of large flexible retractors which do not traumatize the tissue, and which reflect the light in upon the field.

The best procedure is first to locate the ureter where it crosses the iliac vessels and then to follow its course until the point of obstruction is reached.

If the ureter is much distended and especially if its contents be infected, a temporary clamp should be placed above the obstruction to prevent the leakage of the ureteral contents into the wound, while the stone is removed.

Whether or not the incised ureter should be sutured depends upon its accessibility, the length of the incision, the thickness of the ureteral wall and the amount of adjacent tissue which may be available to cover over the opening. In the opinion of the author, it is advisable to use a oo chromic catgut suture and to close the opening, although apparently little harm is done if the edges are not closely approximated.

The question of drainage depends upon the judgment of the individual operator. In the majority of cases the small rubber cover of a cigarette drain inserted at a point near the incision will be sufficient to draw the fluid to the external wound in case there should be leakage. A permanent urinary fistula seldom occurs after the excision of a stone.

If the muscles have been divided, they should be closely approximated and sutured with chromic catgut.

If the stone is within the vesical portion of the ureter, an easier method of approach is by way of the urinary bladder when the ureter may be split and the stone dislodged without any apparent interference with the function of the ureter. The author has successfully used this method in a number of cases.

If the patient be a woman and the stone be lodged in the lower part of the ureter, it can often be palpated by vaginal examination. In such cases the removal of the stone is easily accomplished by means of an opening through the lateral wall of the vagina, through which the ureter may be palpated and brought down with hooked forceps and the stone excised. The author has recently used this method four times, removing the stones in three cases, the fourth stone being missed because at the time of the operation it was dislodged upward out of reach. By this method there is so little traumatism and so little disturbance of the tissues that the post-operative discomfort is reduced to a minimum and the patient is able to be up and around in a few days.

Buerger (Am. J. Surg., 1913, xxvii, 151) has suggested a method of dilating the ureter in cases of narrowing or stricture or to release impacted calculi. His procedure consists in using "dilating metal olives" varying in size from 6 Fr. to 16 Fr. and the D'Arsonval current, the smaller pole of which is applied to the ureter, the larger to the abdomen. He claims not only that this is an easy and painless method but also that it can bring about greater dilatation than bougies.

Occasionally a ureteral stone may be very movable and a change of the position of the patient may change its location, as is illustrated by the following description of a case in which a calculus had formed between two congenital strictures of the ureter.

An American, a laborer, aged 18 years, was admitted to the hospital in May, 1911. His family history was negative. He denied lues and gave a past history of general good health, except for the presnet trouble. The patient had had urethritis two years before and a second attack two months before entering hospital. He had had attacks of pain in the left side about once a month ever since he could remember and his mother stated they had occurred ever since he was an infant. These attacks were associated with pain running into the scrotum and penis, the duration varying from a few minutes to several hours. The last attack, two weeks previous, came on suddenly while he was at work, lasted for 12 hours, was very severe and was accompanied by

chills and elevation of temperature. For the past three or four years the urine had contained blood which appeared at times without any

FIG. 146.—Double congenital stricture with movable calculus between points of constriction.

accompanying pain. For the last 10 months, however, there had been no blood in the urine.

Physical examination showed a normal, well-developed young man. Rectal examination showed the prostate, small, smooth and not tender. Seminal vesicles not palpable. Slight fullness just above prostate in region of bladder. No tenderness along course of left ureter. Kidney not palpable. Urine contained a few leucocytes and some red cells.

A radiograph showed a shadow in the lower portion of the left ureter, about the size and shape of an almond, as is shown by the cut (Fig. 146).

Operation.—With the patient in a moderate Trendelenburg position the usual oblique incision for extraperitoneal exposure of the lower end of the ureter was made. The ureter was exposed and palpated but no stone was detected. Further exposure revealed a widely dilated ureter which was opened, a considerable amount of fluid escaping; a probe was inserted down toward the bladder, but no stone could be felt. The probe was then passed toward the kidneys but no stone was discovered. The opening in the ureter was enlarged for the insertion of the index finger, which could easily be done, as the ureter was about the size of a human small intestine. A short distance below the opening a constriction in the ureter was detected which seemed quite narrow and through which a small steel probe was passed into the bladder. In the supposition that perhaps the stone might have been forced through into the bladder, the latter was opened but no stone found. The author felt sure it could not have passed through the urethra without the patient's knowledge, because of his urethritis, and since the radiograph demonstrated a rather large stone. After closing the bladder it was decided to try another X-ray examination.

The anæsthetic was changed from nitrous oxide to ether and the patient sent to the X-ray laboratory. The first picture of the lower ureter, where the shadow was seen before, was negative. A second picture of the upper ureter and kidney showed the stone in the upper part of the ureter. The patient was returned to the operating room and placed in a nearly upright position in the hope that the stone would drop down to the lower end of the ureter, but it could not be reached. A third incision was made in the lumbar region and the pelvis of the kidney exposed. The stone was not in the renal pelvis, but could be detected at a point just below a narrowing and constricted portion of the ureter. From this point the stone was pushed downward and was finally removed at the first incision. The ureter was closed with oo chromic catgut. The patient made a good recovery without any return of his attacks of pain.

The change of position at the time of operation, together with the fluid in the ureter caused the stone to move up out of the field of operation. After the ureter had collapsed it was held in its new position and could not again be moved by simply changing the position.

If the ureteral calculi are bilateral as often happens, the same condition arises as in the case of bilateral renal calculi and the same treatment is indicated as that already described for the latter condition. If anuria develops, nephrotomy should be done early.

Anuria.—Anuria, due to the presence of renal calculi in one or both kidneys, occurs in only a small per cent. of calculus cases, but when it does occur the prognosis is usually grave.

The X-ray will generally determine whether the anuria be due to bilateral complete obstruction from the presence of calculi on both sides. If there be anuria and calculus can be demonstrated on one side only, the question as to whether the anuria is reflex or is due to the presence of only one kidney which is obstructed must be determined if possible. If the ureters be catheterized with X-ray catheters, a radiograph will show the direction of the second ureter, which if normal will probably mean the presence of a second kidney, and the condition may be diagnosed as reflex.

Diagnosis.—Complete absence of urine in the bladder will determine the diagnosis. Uremic symptoms rarely develop in less than 48 or 72 hours. Loree (Lancet-Clinic, 1912, cvii, 210–213) states that Cunningham and Watson's collection of 62 cases shows the average time before the development of uremia to be from five to six days.

Treatment.—The treatment of anuria must be prompt. If it be caused by complete obstruction, nephrolithotomy or ureterolithotomy must be performed at once. If, however, the risk seems too hazardous for an attempt to remove the obstruction, then double nephrotomy with drainage should be performed at once, the removal of the obstruction being deferred. Not more than 20 per cent. of these cases recover without operation, while statistics show the percentage of recoveries after operation to be above 50.

HYDRONEPHROSIS

Etiology.—When the pelvis of the kidney and the calices are abnormally dilated with urine, the condition is known as *hydronephrosis.* This term is used for different varieties and degrees of the condition which is always due to some resistance to the outflow of urine.

Hydronephrosis may be congenital, or acquired, and it may be caused by abnormal conditions without as well as within the kidney or ureter. A stone interfering with the free outflow of urine is the most frequent cause within the kidney itself. A tumor of the pelvis or a blood clot in the same region have been known to cause this condition, while within the ureter the obstruction may exist at any point through-

FIG. 147.—Hydronephrosis caused by aberrant blood vessel.

out its course and may be a structural defect, an arrested calculus, a blood clot, or a tumor.

Obstruction may result from the pressure of an abdominal tumor, or of an inflammatory deposit outside the ureter. Hydronephrosis may result also from some obstruction in the lower urinary apparatus,

such as stricture of the urethra, prostatic hypertrophy, or a bladder tumor. In such cases the bladder and ureters are distended, and as a rule both kidneys are affected.

A majority of the cases of hydronephrosis are produced by factors which exist at birth, among which are the remains of the valves which exist normally in fœtal life just at or below the uretero-pelvic junction, malformations of the ureter, movable and horseshoe kidney.

Fig. 148.—Hydronephrosis due to impacted calculus at beginning of ureter.

A congenital stricture of the ureter or an anomalous blood-vessel which passes over the upper part of the ureteral tube and diminishes its lumen are well-known causes of hydronephrosis. A striking example of this is shown in the accompanying cut (Fig. 147).

Acquired hydronephrosis may be caused by compression from without, by tumors, by extensive effusions, by ligatures in the resection of a carcinomatous uterus. Trauma of the ureter also, even though it cause but a slight laceration, may, in after years, result in a stricture

and consequent hydronephrosis. Acquired hydronephrosis may be due also to causes within the ureter, such as an impacted calculus or tumor (Fig. 148). Ureteritis, from whatever cause, may result in stricture and subsequent hydronephrosis. Experimentally it has been shown that complete ligation of a ureter, even if but temporary, causes hydronephrosis, with occasional simple atrophy, while incomplete ligation of a ureter will always cause hydronephrosis.

Pathological Changes.—The continuous retention of a large amount of urine in the pelvis of the kidney gradually causes dilatation and thinning and finally sclerosis of the sac. The distending cavity encroaches gradually upon the substance of the kidney and the blood-vessels, causing anæmia and atrophy. When the obstruction is permanent and complete, the condition is known as a closed hydronephrosis. In such a case the kidney substance is totally destroyed and the organ becomes a closed cyst with thin walls and sometimes reaches a large size. A compensatory hypertrophy of the opposite kidney is usually found. In lesser degrees of dilatation caused by pressure in the lower urinary tract, the condition may be bilateral. In these cases the dilatation is not so marked and the ureter and bladder share in the increase in size. Bilateral distention due to obstruction in the lower urinary organs is generally accompanied by infection of the kidney resulting in pyonephrosis.

Symptoms.—Hydronephrosis may exist for years without giving rise to obvious symptoms as the slight attacks of renal colic due to the intermittent pressure may pass unnoticed. In the late stages the presence of a tumor in the loin gives a clue to the diagnosis.

On the other hand pain may be the first symptom noticed, search for its cause directing attention to the tumor. If the kidney is greatly enlarged the pain may be constant and intense while, as noted above, in lesser enlargements it may be entirely absent or may occur in intermittent attacks of renal colic. As is true of renal colic from any cause, relief from pain is usually followed by the passage of a large amount of urine of low specific gravity, pale in color, and sometimes containing blood and mucus.

In children, complete retention may be present, due to a congenital stricture of the urethra or the ureters.

Diagnosis.—A large palpable tumor in the region of the kidney always suggest hydronephrosis, this diagnosis being more probable in the case of a fluctuant tumor. In the differential diagnosis, the cystoscopic examination of the bladder with ureteral catheterization is of the

greatest value, while for further assurance pyelography and functional tests are used. For pyelography a solution of 10 per cent. collargol is injected into the pelvis of the kidney, the solution being drained off as soon as the X-ray picture is taken. For the functional test phenol-sulphonephthalein has been found most satisfactory. A large fluctuating tumor in the lumbar region may result from either hydronephrosis or an ovarian cyst. If doubt remains, the differential diagnosis in such a case may be made by making an exploratory puncture with a fine needle and drawing off some of the fluid for examination. Great care must be exercised in carrying out this procedure as fatal septic peritonitis may result if urine escapes into the abdomen.

Prognosis.—If the hydronephrosis is unilateral and there are no complications, a favorable prognosis may be made. Bilateral hydronephrosis will usually result in fatal uræmia, so that a good outcome from this condition can rarely be expected.

Anuria and uræmia caused by the obstruction of the ureter, pyonephrosis resulting from infection, and rupture of the sac from its extreme distention are complications which may arise in any case and which will render the prognosis extremely grave.

Treatment.—The advent of a reliable functional test for the kidney has changed the treatment in cases of hydronephrosis, as the extent of damage to the kidney may thus be determined with considerable accuracy. Surgical intervention is indicated in nearly every instance, for although aspiration is sometimes beneficial, on account of the great danger of peritonitis it should be used in extreme cases only.

If the functional test shows that the condition is unilateral and that the affected kidney has nearly or quite lost its functional power, while the opposite kidney is in fairly good condition, nephrectomy should be performed. If the hydronephrosis is the result of an impacted stone in the pelvis of the kidney, a pyelotomy may be done and the kidney preserved. Nephrectomy is the operation of choice rather than nephrotomy because, as numerous statistics show, the former has the lower mortality rate and requires a shorter time for convalescence. It must be remembered that a kidney which is slightly under par will do much more work after a badly diseased one on the opposite side has been removed. In any case, however, the choice and extent of the operation must depend upon the cause and nature of the lesion.

If the hydronephrosis be due to anomalous blood-vessels, the vessels must be ligated and divided. If the condition is caused by an abnormally movable kidney, nephropexy should be performed. A stricture

may be dilated. A calculus anywhere in the urinary tract should be removed.

RENAL INFECTIONS

Etiology.—Renal infections may be caused by bacteria which are brought to the kidneys from distant parts of the body through the blood- or lymph-channels; they may invade by extension from the bladder and ureter; or may be the result of direct invasion from the immediately surrounding structures. Any suppurative process in any part of the body, such as a carbuncle, a boil, an infected finger, a peritonsillar abscess, etc., may be followed by an infection of the kidney or of its pelvis. An obstruction to the outlet of urine in either the urethra or the ureters may act as a predisposing cause, as may, in fact, any condition which lowers the resistance of the kidney, such as an abnormality, an injury or malposition of the kidney or ureters, acute congestion, the presence of calculi, movable kidney, etc. The predisposition of injured kidneys to infection has been shown by Brewer who, at the 17th International Congress of Surgeons, showed by reports of numerous experiments, that when animals which had one injured kidney were inoculated with pathogenic organisms, 8 out of 16 developed surgical lesions in the injured kidney only, these lesions varying from septic infarcts and localized abscesses in the parenchyma to diffuse suppurative pyelonephritis and necrosis.

The bacillus coli communis is the most frequent cause of renal infection, but many other microörganisms invade the kidney, among which may be especially noted staphylococcus aureus and albus, streptococcus, gonococcus, pneumococcus, bacillus pyocyaneus, proteus vulgaris, typhus bacillus and tubercle bacillus.

Brewer differentiates three types of renal infections, the fulminating, the intermediate, and the mild. Fulminating infections are ushered in by rigor, the sudden rise of temperature to 104° or 105°F., a rapid pulse, and pain which is usually confined to the costovertebral angle on one side. Delirium soon ensues and is followed by coma and death. The urine contains albumin, blood and a few pus cells; the flow from the affected kidney is scanty, but from the other kidney it may be normal, or even copious.

In infections of the intermediate type the symptoms are less severe, but the condition is serious and may prove fatal; in these cases the first symptom is usually profuse hematuria, which may subside in

from 24 to 48 hours or may continue and be accompanied by severe pains which simulate renal colic.

Renal infections of the mild type—the so-called "idiopathic pyelitis"—occur after surgical operations or during the course of infective diseases. In these cases pain may be absent and the only sign of the condition may be a sudden and unaccountable rise in temperature (Nitch, Practitioner, 1914, xcii, 182).

Pyelitis.—What has already been stated regarding renal infections in general applies to infections of the renal pelvis. Indeed it is difficult, if ever possible, to distinguish between a true pyelitis and pyelonephritis, since the invasion from the pelvis into the calices and the substance of the kidney may be very gradual. For this reason it is also difficult to determine in any case of renal infection to what extent the pelvis is involved.

As is true of other renal infections, the most frequent cause of pyelitis is the colon bacillus.

Pyelitis follicularis is a rare condition regarding the causation of which no definite conclusion has as yet been reached. Kretschmer reports a case in a recent number of the American Journal of Urology and appends reports of seven other cases found in the literature at his command (Kretschmer, Am. J. Urol., 1914, x, 113–120).

Diagnosis.—Acute pyelitis is attended by a feeling of general malaise, chills—sometimes severe—increased temperature, and soreness of the muscles and joints. Occasionally there is marked tenderness in the region of the kidney, but as this symptom may not be present the source of the trouble is often overlooked. The urine is turbid, contains leucocytes and is generally loaded with bacteria. In acute stages there may be vomiting and other pronounced gastric symptoms.

The diagnosis is generally determined by an examination of the urine and by the exclusion of other conditions which may produce similar symptoms.

The diagnosis of pyelitis follicularis can be made only by an operation, which usually reveals the presence in the renal pelvis of many small nodules about the size of millet seeds, these nodules or follicles containing or being surrounded by numerous blood-vessels. In the opinion of some authors these follicles may be present for a time and may then gradually disappear (Kretschmer, *loc. cit.*).

Prognosis.—Death seldom follows an uncomplicated inflammation of the pelvis of the kidney. Pyelitis has a tendency, however, to become chronic, and the gravity of the prognosis is therefore increased since

chronic pyelitis may last for a long time and by extension may involve other parts of the kidney.

Treatment.—Pyelitis seldom demands surgical intervention. The usual treatment includes the administration of urinary antiseptics, especially hexamethylenamin in large doses, laxatives, large quantities of water and rest with a restricted diet. If the condition becomes chronic or shows a tendency to intermit, autogenous vaccines will sometimes be beneficial, though they are seldom of any use in cases of acute pyelitis. Irrigation of the kidney pelvis with a nitrate of silver solution produces apparently good results.

The use of liquor aluminum acetate has been strongly advocated by Irvin S. Koll, but Braasch (Texas State J. M., 1914, ix, 305) does not consider this to be more effective than silver nitrate and reports that it has the disadvantage of frequently causing considerable local irritation. He advises using all three methods in conjunction, *i.e.*, urinary antiseptics, autogenous vaccines, and renal lavage.

In his excellent treatise on infections of the kidney presented at the 17th International Congress, Rovsing recommends salol as the best disinfectant for the pyelitis of pregnancy. He suggests the following treatment for these cases: If high fever, rigors, and general indisposition be present, procure an outlet for the infected urine by catheterizing and draining the renal pelvis; irrigate with one-half of 1 per cent. solution of nitrate of silver, and repeat this treatment from time to time until the confinement is over. If these measures prove unsuccessful, artificial delivery should be induced or a nephrotomy performed. Pyelotomy through a lumbar incision should be the final resort after all other measures have failed.

In cases of pyelitis follicularis Kretschmer (*loc. cit.*) suggests that if the kidney is perfectly normal, "measures other than nephrectomy should be instituted, unless, of course, there be danger due to loss of blood on the part of the patient." Under certain conditions pelvic lavage or vaccines may be beneficial.

Pyelonephritis.—Pyelonephritis is often an extension of pyelitis and can be distinguished from the latter only by the graver symptoms by which it is usually characterized.

The suppurative form of the disease generally follows cystitis or other diseases of the lower urinary tract, though it may be caused by the presence of calculi. "Morris states that in the large majority of the cases suppurative pyelonephritis originates in an ascending infection;

in some, however, it reaches the kidney through the blood current" (Watson and Cunningham, *loc. cit.*).

Symptoms.—Pyelonephritis is usually attended by severe chills, sweats, nausea, vomiting, rise in temperature, dull pain, and a characteristic blood count which shows marked increase of leucocytes. Occasionally the symptoms may simulate those of typhoid. Suppuraative pyelonephritis, known as "surgical kidney," is accompanied by symptoms which suggest "a combination of urinary sepsis (toxæmia) and uræmia" (Chetwood, *loc. cit.*).

Prognosis.—The prognosis depends upon the severity of the infection and its extent, *i.e.*, whether or not it be unilateral. Renal insufficiency is the most serious complication to be looked for, as when this occurs the prognosis becomes extremely grave.

Treatment.—General therapeutic measures should be employed before resorting to operation. A light diet, free evacuation of the bowels, hot applications over the loins, the copious drinking of distilled water, and the administration of urinary antiseptics are the remedies to be tried first.

Should there be evidence of abscess formation, however, an immediate operation consisting of exploration and drainage is required. As pyelonephritis is often bilateral, nephrectomy should not be performed unless it can be demonstrated with certainty that the other kidney is normal.

Pyonephrosis.—Pyonephrosis is a suppurative condition of the kidney which may be a sequence of pyelitis, of pyelonephritis, or of an infected hydronephrosis. It is frequently associated also with tuberculosis and calculus. The kidney as a rule is enlarged and is readily palpable, the pelvis and calices are distended and filled with pus or infected urine, and in cases associated with tuberculosis the ureter is usually thickened.

Symptoms.—The chief symptoms of pyonephrosis are pyuria and pain. There may be only a slight tenderness, the pain may be dull in character, or it may be severe, especially in those cases in which the ureter is obstructed by a renal calculus or by a stricture.

As a rule the urine has a milky appearance, is of low specific gravity and contains albumin and pus. If the trouble is of long standing there is generally a palpable tumor, and the muscles of the side involved are stiff and rigid. "In cases of closed pyonephrosis, the urinary symptoms are lacking and some of these may exist only with a tumor as their chief symptom" (Chetwood, *loc. cit.*).

Treatment.—Pyonephrosis always demands surgical treatment. Nephrotomy and drainage may suffice, but if the substance of the kidney be largely destroyed and the other kidney be functionating, nephrectomy should be performed. If the patient's condition be grave, it is best to perform the operation in two stages, first making a nephrotomy and establishing drainage, the nephrectomy being deferred until the patient can more safely endure it. Watson and Cunningham (*loc. cit.*) consider nephrotomy to be the operation of choice, free drainage being established by breaking down all the walls which intervene between the pus sacs. In spite of the possibility of fistula, these authors consider this to be the only justifiable procedure (*a*) when the surgeon is not absolutely assured of the integrity of the other kidney, and (*b*) when there is a focus of infection in the lower part of the urinary tract as a result of which the other kidney may subsequently become infected.

If the condition be bilateral, especially in cases of bilateral calculi, it is advisable to remove the stones by either nephrotomy or pyelotomy, the operation being performed in one or two stages according to the condition of the patient.

Perinephritis and Perinephritic Abscess.—The perirenal fat and connective tissue have but low powers of resistance to outside infections, and they therefore readily become involved when an infection is carried to them from some distant focus through the blood- or lymph-stream, when the kidney or other adjacent organ is infected, or when they are directly contused by severe trauma in the lumbar region.

Perinephritic abscess of embolic origin may result from suppurative cholecystitis, abscess of the liver, spleen, or pancreas, from typhoid fever, appendicitis, lung abscess or empyema (Guiteras, *loc. cit.*).

The symptoms of perinephritic abscess are those which always accompany an abscess, wherever situated. Pain under the costal margin of the affected side is an almost constant symptom but varies in intensity with the degree of inflammation, though severe pain is usually produced by pressure in the costovertebral angle. The patient is anæmic, may be emaciated, walks with a slight stoop toward the affected side, is afraid to bend over, and is quite likely to press his hand against the affected region for support when moving.

Examination will usually disclose a slight fullness in the loin, although this may not be present in the early stages of the condition. The muscles of the back and abdomen are rigid on the affected side, and the patient finds it painful to lie either on that side or on his back.

The course of the temperature will show evidences of chronic

septic absorption, being normal in the morning and rising 1 or 2 degrees in the evening.

In chronic cases the only symptoms may be anæmia, loss of appetite, evening fever, and pain in the costovertebral angle, and yet at operation considerable pus may be found.

The diagnosis can often be confirmed by aspirating or, in doubtful cases, by an X-ray examination.

Treatment.—If the condition be inflammation without pus formation, absolute rest in bed with the application of heat over the painful area may suffice. If there be fluctuation, however, and the presence of pus be reasonably certain, drainage should be established at once, for unless this is done the abscess may break through into the peritoneal or the pleural cavity with fatal results, or a fistula may result if it be allowed to rupture into the loin.

Before closing the wound the adjacent kidney should be carefully examined for calculus.

Septic Infarct.—Septic infarct or "focal suppurative nephritis" (Whiting) is of embolic origin, the infection being brought to the kidney through the lymph- or blood-stream. It may be a sequence of any one of many distant infections, such as peritonsillar abscess, paronychia, prostatic abscess, etc. Brewer has shown experimentally that traumatism of the kidney acts as a predisposing cause and that probably in the unilateral cases some local lesion always exists.

Septic infarct is marked by notable pathologic changes. The kidney is swollen and its surface is covered with many small reddish areas which are slightly raised above the surface. Sometimes a group of these areas may coalesce. Later, true abscesses are formed and the surface of the kidney is studded with minute pus foci surrounded by zones of hemorrhagic infiltration which separate them from the still healthy tissue.

Symptoms.—The onset of acute unilateral septic infarct is sudden and is marked by a chill, a quick rise of temperature, pain in the abdomen and back, and a high leucocyte count. Usually the urine from the affected kidney contains blood and pus.

In subacute cases the onset is so insidious that the kidney lesion may be overlooked for a time in the presence of a severe infection elsewhere.

Sometimes the symptoms simulate those of some abdominal lesion so that a mistaken diagnosis may be made and the abdomen opened before the error is discovered. In the case of an infarct of the right kid-

ney, especially, tenderness and muscular rigidity may lead to a diagnosis of acute appendicitis.

Pain or tenderness in the costovertebral angle is an almost constant sign and if present may establish the diagnosis.

Treatment.—It was formerly thought that surgical intervention was always indicated in severe cases of acute unilateral septic infarct, and nephrectomy was advised as the operation of choice as it seemed hardly possible that the various foci could be effectively drained by nephrotomy. In the author's opinion, however, a decision to operate should be most cautiously made. It is difficult to establish with certainty whether the condition is unilateral or bilateral, and it has been our experience that most cases get well without operation.

The author formerly removed the kidney whenever he could establish the diagnosis and his cases recovered. Recently, however, he has seen just as severe cases recover without operation. More than once after having decided to operate upon a case with a severe acute hemic infection, with a temperature of 106° F., chills and fever, localized tenderness, high leucocyte count,—in fact with all the symptoms of an overwhelming intoxication, the patient has gradually grown better while waiting for a favorable time for operation and has eventually recovered.

Those cases should be operated upon, however, in which after the first severe onset there are repeatedly recurring attacks of chills and fever. After establishing the presence of a second functionating kidney a *nephrectomy* should be performed, as in most cases *nephrotomy* would not suffice to drain the multiple abscesses.

Tuberculosis.—Tuberculosis is found to constitute about 30 per cent. of the various surgical infections of the kidney. It occurs most frequently between the ages of 15 and 35, although cases are recorded of its occurrence at as early an age as two and one-half months and as late as 75 years (F. Tilden Brown).

In unilateral tuberculosis of the kidney, the source of the infection is hematogenous in practically all cases. The tubercle bacilli enter either through the pulmonary or alimentary tract and the infection descends along the ureter to the bladder, as shown in the cut (Fig. 149). In the late stages an ascending infection may occur in the opposite side. Slight traumatism may act as a predisposing cause. Cases are on record in which the kidney has become involved by direct invasion from tuberculous processes in the vertebræ. In more than 75 per cent. of the cases, the lesion is unilateral and remains so on an average of from three to four years. According to Israel, 66⅔ per cent. of the cases are

FIG. 149.—Tuberculosis of kidney, extending along ureter and bladder.

in women, though other statistics would indicate that it is more prevalent in men. However, the majority of cases in our own experience have been in women. From the recorded cases it would seem that the right side is involved more frequently. Heredity does not seem to play an important rôle in this disease.

Symptoms.—The most frequent symptom of tuberculosis of the kidney and one which occurs in more than 90 per cent. of the cases, is some form of vesical irritation. This irritation may consist of a burning sensation, especially in the perineum in men. Nearly every one of our own male cases has complained of this symptom. Micturition is very frequent and in many cases there is severe tenesmus. This is often the only symptom that is present, and the patient does not complain of any discomfort whatsoever in the region of the kidney. As frequent micturition and even tenesmus are often attributed to many other causes such as "cold," "catarrh of the bladder," "malpositions of the uterus," etc., and as a consequence are too often treated along these lines, the true cause may not be detected until late in the disease. In some cases the onset of the disease is marked by a renal colic, due to the obstruction of the ureter by pus. Hematuria is quite frequent, and is nearly always painless. The amount of pus varies from a few cells to a heavy sediment. In many cases before the urinary symptoms develop there is a feeling of malaise, with occasionally a slight temperature and an increasing pallor; and the patient complains of becoming more easily fatigued than usual.

Diagnosis.—As no single or combined chain of symptoms is always present an absolute diagnosis from symptoms alone is impossible. The pathognomic sign is the presence of tubercle bacilli in the urine, but these are not always easily determined, and when found their source must be correctly interpreted. This can be done only by use of the cystoscope and ureteral catheter. In tuberculosis of the kidney tubercle bacilli can be detected in the urine in about 75 per cent. of the cases, but if tuberculosis is suspected and the tubercle bacilli cannot be demonstrated, guinea-pig inoculation should be resorted to. If this is done by Bloch's method the results can be obtained in a much shorter time than by the older method,—that is in about 10 days as compared to six weeks by the subcutaneous or intraperitoneal methods.

Bloch's technique as quoted by Keene and Laird (Am. J. Med. Sc., 1913, cxlvi, 360) is as follows: "A twenty-four hour specimen of urine is collected from the suspected case in a large sterile bottle, without the addition of a preservative. About 10 cc. of urine from the lower por-

tion of the specimen are placed into each of two centrifuge tubes and centrifugalized for from two to four hours, dependent upon the speed of the centrifuge, when the supernatant urine may be poured off, leaving the sediment in the bottom of the tubes.

"From the sediment in one of the tubes, slide smears are made, which are then fixed, stained and examined microscopically for pus, blood, and bacteria, especially acid-fast bacilli (Gabbett's method of staining the tubercle bacilli was employed in this work).

"A suspension of the sediment in the second tube is prepared by shaking with 5 cc. of sterile water. Two healthy normal guinea pigs are inoculated. The inguinal glands of the pigs are first slightly injured and thus rendered more susceptible to the attack of the tubercle bacillus, by pressing and rolling them between the forefinger and thumb for a few moments prior to the inoculation. 2½ cc. of the prepared suspension, unheated, are then injected into each of the two pigs, subcutaneously, in the inguinal region directly below the glands. Pressure is again applied for a short time and repeated on the two days following the injection.

"Ten days after the inoculation, one of the pigs is chloroformed and the inguinal glands on the injected side removed. These may be either sectioned, stained and examined for tubercle bacilli or more simply and quite as reliably finely macerated and pressed out between two microscopic slides and fixed, stained and examined immediately.

"In the majority of positive cases the microscopic examination of the inguinal glands results in the discovery of the tubercle bacilli in a few minutes. In some cases, however, in which the tubercle bacilli have been probably few in number or of low virulence, the resultant inguinal involvement is so slight that the bacilli may escape detection by a cursory examination and therefore a thorough search of every portion of the inguinal tissue should be made before a negative diagnosis is given. In order to control the Bloch method of inoculation, the second pig was allowed to live the required six weeks and then examined for general tuberculosis."

If the cause of pus in the urine cannot be traced to direct infection from without or if the X-ray does not disclose stones in the kidney or ureter, then tuberculosis is most probably the cause of the pyuria. Occasionally tuberculosis will be found combined with nephrolithiasis. When the X-ray is used as an aid to diagnosis, it is well to remember that occasionally tuberculous caseous deposits will cast a very distinct shadow which will simulate stone, as is shown in the cut (Fig. 150).

Not infrequently the tuberculous kidney is not enlarged, and in the later stage it is sometimes even smaller than normal, the healthy kidney being more distinctly palpable and being sometimes definitely tender. For this reason it has happened that the compensatory hypertrophied and tender kidney has been operated upon under the supposition that it

FIG. 150.—Caseous degeneration of kidney in which the shadow simulates calculi.

was the diseased one. In the cavernous variety of tuberculous kidney in which there is a large pus cavity there is generally a very marked tender tumor mass in the region of the kidney. In this variety there will be periods in which the bladder symptoms are much improved, the urine

much clearer, but coincident with this will be a rise in temperature and increased tenderness in the region of the kidney, the result of ureteral obstruction. If rectal or vaginal palpation reveals a hard cord-like tender ureter, one may with certainty conclude that it is tuberculous. In such a case the cystoscopic picture of the bladder wall will show the fixed and inflamed ureteral orifice on the side of the diseased kidney.

Prognosis.—In unilateral tuberculosis of the kidney without involvement of other organs the prognosis is extremely good after nephrectomy, and even with bladder involvement many cases recover after the removal of the diseased kidney; in fact, all tuberculous bladders will improve for a while at least after nephrectomy. If both kidneys are involved, however, or if other organs are infected, nephrectomy offers but temporary relief.

The immediate mortality rate should be extremely low. In our own series we have not had an operative death. The causes of death following operations are pulmonary involvement, tuberculous peritonitis, or secondary involvement of the other kidney.

Treatment.—Surgical treatment alone offers hope of permanent relief in cases of unilateral tuberculosis of the kidney when there is no pronounced involvement of other organs. Medical treatment is at best but palliative. Wildbolz of Berne, as quoted by Eisendrath (Interstate M. J., 1913, xx, 299) "treated in a non-operative way 316 cases. Fifty-eight per cent. died within five years. The subjective symptoms continued with but slight remissions. Apparent cure occurred in a small number, but lasted more than five years in only 7 per cent. A true cure was observed in only one of the 316 cases."

The diseased kidney should be removed as soon as the diagnosis is definitely established. Resection of the kidney has not proved satisfactory, and nephrotomy should be done only as a temporizing method in extreme cases, preparatory to a later nephrectomy. In most cases, however, a nephrectomy can be the primary operation.

There has been much discussion lately as to the best disposition of the diseased ureter. In certain cases it seems advisable to remove it at the time the nephrectomy is done, but in most cases the simple ligation and cauterization of the stump with the actual cautery or with carbolic acid, is all that is necessary. It is impossible to remove all the tubercle bacilli by a surgical operation. All that can be done is to remove the principal nidus of infection and thereby make it possible for the patient to take care of the rest.

As a rule drainage is not necessary and, as has recently been shown

by Mayo, often closing the wound and filling it with saline solution if there has been soiling, will be followed by primary union.

Unless there are very marked ulcerations in the bladder, the vesical symptoms improve almost immediately.

It is advisable in all these cases to follow the operation by tuberculin treatment (Koch's old). A comparison of the cases which we have treated by this method with those that were not given the tuberculin convinces us of the value of this treatment. These patients should be given every opportunity for the improvement of their general health. General hygienic rules for treating tuberculosis should be followed in all these cases.

When both kidneys are involved and it can be demonstrated that one is much more involved than the other, the one most diseased should be removed, after which the other will be greatly improved as may be demonstrated by functional tests and the improvement in the general condition of the patient.

Under any circumstances before doing the nephrectomy it is imperative to determine that the other kidney is functionating. The best method at present for determining the functionating capacity of the kidney is the phenolsulphonephthalein test as developed by Rowntree and Geraghty which is described under another heading.

MOVABLE KIDNEYS

The terms *floating kidney* and *movable kidney* are often used interchangeably. Strictly, however, a floating kidney is one that is "completely enveloped by peritoneum, which then passes backward to the vertebral column as a double layer, forming a *mesonephron*, which permits of movements taking place" (Gray); while a *movable kidney* has an abnormal degree of mobility *behind the peritoneum*.

Whether or not a movable kidney should be considered pathological depends entirely on the individual case. Some kidneys which are freely movable within a wide range do not give rise to the slightest discomfort; whereas, a kidney which moves within a very narrow range may so flex or obstruct the ureter as to give rise to pain, sometimes severe renal colic, even Dietl's crises.

For many years it has been a too common practice to anchor a movable kidney, in cases with vague symptoms, if such a kidney could be demonstrated; but it has been shown in many of these cases either that the anchoring of the kidney was not effectual or that the symp-

toms for the relief of which the operation was performed were not in any way caused by the mobility of the kidney. It therefore becomes of paramount importance to determine in each case what part of the existing disturbance may be due to the displacement of the kidney and what may be the result of other causes.

If catheterization of the ureters and the injection of sterile water or of boracic solution reproduce the symptoms complained of, it is strongly probable that the conditions from which relief is sought are at least associated with the kidney. A radiograph taken after the injection of an opaque solution such as collargol, will show a constriction or kinking of the ureter if it be present, and if the patient be in an upright position may disclose a prolapse of the kidney; but many of these cases are not relieved of their symptoms by anchoring the kidney. The discovery of a low-lying kidney does not always signify that the kidney is causing any symptoms unless it can be demonstrated absolutely that the symptoms disappear when the kidney is held temporarily in its normal position.

As ptosis of other organs can be demonstrated in most cases of movable kidney, it is difficult to ascertain what particular organ is responsible for the trouble. The symptoms often closely resemble those caused by a lesion of the gastrointestinal tract. Occasionally the symptoms are traced directly to the movable kidney and the prevention of this mobility will relieve all the symptoms.

Symptoms.—The symptoms may center about the kidney, about the more near-lying organs, or they may be general throughout the nervous system. As already stated, a movable kidney may not betray itself by any symptoms, the condition, if discovered at all, being disclosed in the course of a general examination.

Pain is usually the most prominent symptom and may range from a changeable constant dragging sensation to sudden sharp attacks of very severe pain, the so-called "Dietl's crises," and if on the right side may cause a mistaken diagnosis of appendicitis. The attacks of pain are followed usually by polyuria. There may be tenderness in the back and often a tender kidney may be palpated. Occasionally gastrointestinal symptoms, vomiting and nausea may be the only signs of the trouble.

Treatment.—The treatment of movable kidney is either mechanical or operative. It may be possible to hold the kidney in place by external pressure exerted by belts, bands or adhesive straps. The patient should

be well nourished so that the amount of fat about the kidney may be increased, as this will help to prevent its free movement.

If the relief secured by mechanical means and general therapeutic measures proves to be incomplete or only temporary, then the radical operation of anchoring the kidney must be performed. Many different methods for anchoring the kidney have been devised. The purpose of each is to permanently fix the kidney in a position as nearly normal as possible. The fact that so many methods have been advised shows how difficult it is to obtain this very desirable end. It has been the author's custom to make a vertical incision, exposing the kidney; to split the capsule and dissect it back for about ½ in. on each side and then with chromicized catgut to sew the split flaps of the capsules to the aponeurosis and fibers of the lumbar muscles, being careful not to place the kidney in so high a position that it would constantly be in apposition with other structures, yet sufficiently high to assure easy drainage of the kidney pelvis. In the majority of cases this method will hold the kidney in its proper position. Alteration of posture after the method of Goldthwait is recommended by Cabot and Brown (Boston M. & S. J., 1914, clxxi, 369) and might be tried in suitable cases.

ESSENTIAL HEMATURIA

The term "essential hematuria" is applied to the class of cases in which there is bleeding from the kidney, but in which no pathological condition is demonstrable. It is difficult to conceive of a hematuria without a pathological lesion, and simply because it is impossible to demonstrate it in all cases does not mean that a lesion does not exist. *Renal hematuria is always pathological.* Gradually new causes are being discovered which could account for the bleeding but which heretofore have not been demonstrated, or at least have been overlooked. Among these should be mentioned the renal varix described by Fenwick in 1904, sometimes spoken of as an angioma of the renal papillæ. Since then many others have found the condition which he describes, but this does not explain the cause of all the cases of so-called essential hematuria, though it does reduce the number of unexplainable cases.

Another factor which explains this condition is nephritis, both chronic and infectious. Kretschmer (Surg., Gynec. & Obst., 1913, xvi, 34) in a series of 129 cases collected from the literature, found 63 that gave evidence of nephritis. "It does not necessarily follow, how-

ever," as Braasch (J. Am. M. Ass., 1913, lxi, 936) says "that because nephritic changes are found in a bleeding kidney nephritis causes the hematuria." He considers the term "nephritic" an unfortunate one for the type of hematuria now called "essential" and thinks it tends to confuse it with the hematuria accompanying acute and chronic nephritis, which is clinically quite distinct.

Dr. Chute in his discussion of Dr. Braasch's paper (Braasch, *loc. cit.*) added that he thought a focal and not an interstitial nephritis might explain some of these cases of hematuria.

Numerous cases due to hæmophilia also have been reported. Many of the so-called essential hematurias may be explained as secondary to infection, especially infection by the colon bacillus. A review of the recent and voluminous literature on this subject reveals numerous other causes given to explain this condition such as inflammatory alterations in the glomeruli, hyaline degeneration of the blood-vessels, circulatory disturbances and thickening of the capsule, pyelitis granulosa, interstitial lesions of the pyramids, tumors and varicosities of the renal pelvis.

A striking characteristic of this class of cases is that very simple remedies will sometimes stop the bleeding.

Symptoms.—The one symptom, of course, is the bleeding which is nearly always painless unless the ureter becomes blocked with a blood clot, when renal colic will be produced.

Diagnosis.—Diagnosis is difficult because while many grave lesions of the kidney may produce painless hematuria the cause may not be demonstrated for a considerable time. In fact it is only by exclusion that we can arrive at a diagnosis of so-called "essential hematuria." If it has been proven that the bleeding is not caused by any other demonstrable condition, and if a careful history of the case excludes the possibility of injury and the taking of drugs which in themselves might produce the hemorrhage, we may consider the condition to be "essential hematuria."

Prognosis.—The prognosis will depend upon the severity of the case and the length of time the hemorrhage has existed. The bleeding in itself is rarely fatal.

Treatment.—The treatment is as varied as are the speculative causes producing the condition. There is no drug that has a specific action and everything in the way of medicine has been tried. If colon bacilli be present in the urine, vaccines, as recommended by Billings, have proven helpful and have stopped the hemorrhage in a number of cases. The

simple passing of the ureteral catheter, as cited by Hagner, has proven beneficial. The installation of adrenalin, as practised by Young, has also stopped the bleeding in a number of cases. In one of my own cases, in which there had been more or less severe hemorrhages extending over a period of 16 years, the simple passing of ureteral catheters stopped the hemorrhage for two years, when they recurred but were less severe than before.

The operative procedure depends upon the severity of the case; in a severely exsanguinated patient a nephrectomy would be indicated, as any additional loss of blood following a nephrotomy might prove fatal. In such cases a preliminary transfusion of blood should be done. The transfusion has proven all that is necessary in some cases. The giving of serum has stopped the hemorrhage in certain instances. Stripping the kidney of the capsule or simply dividing the capsule, nephropexy and nephrotomy, all have been practised and each has proven remedial. In short, slight operation or manipulation is all that has been necessary in a great many cases.

If the hemorrhage is considerable, an exploratory operation should be made, the kidney exposed and, if no visible lesion can be demonstrated, the kidney should be allowed to remain, the extent of the operation depending upon the judgment and clinical experience of the individual operator.

INJURIES OF THE KIDNEY AND URETER

Injuries of the kidney and ureter, including surgical accidents are relatively infrequent. They may be caused by kicks from man or beast, by blows with blunt instruments, by falls on the back and by crushing accidents, by gunshot or stab wounds. The result produced by these injuries is generally rupture of the kidney which in turn causes severe hemorrhage. Men are naturally more subject to injuries of the kidney than women because of the frequent exposure to the condition which produces it.

Symptoms.—The most frequent symptom is hematuria. If after severe injury in the region of the kidney there is blood in the urine, it at once indicates there has been a lesion of either the kidney or ureter. This hemorrhage may be slight or it may be severe enough to produce collapse. There will usually be great tenderness in the region of the kidney and occasionally if there is extravasation of urine or if a hematoma forms it is definitely palpable. Of course, in a very severe injury

in which the ureter is entirely torn off there may be no hematuria whatever and yet the injury may be most extensive. Occasionally an injury to the kidney will dislodge a stone and the symptoms following may be produced entirely by the calculus rather than the injury.

Diagnosis.—The history of an injury in the region of the kidney, presence of blood in the urine or very pronounced symptoms of shock, even in the absence of blood, would at once suggest the possibility of injury to the kidney and especially if there is marked tenderness and if this is followed by an effusion and tumor.

Prognosis.—The prognosis of course will depend largely upon the extent of the injury. In very severe injuries with severe hemorrhage and extravasation, unless immediate surgical intervention is resorted to, the prognosis is grave. These injuries are often accompanied by injuries of other organs which complicate the chances for recovery. The prognosis will also depend upon the infection that may take place.

Treatment.—In all cases of definite injury to the kidney the case should be kept under very careful observation, especially relative to the amount of hemorrhage taking place and the amount of swelling and extravasation occurring in the region of the kidney. All injuries of the kidney need not necessarily be operated upon as soon as diagnosed. Repeatedly, injuries to the kidney, in which there is marked hematuria will after four or five days entirely clear up and steadily improve without any surgical intervention. Cases, however, in which the hemorrhage is very severe or in which there is evident extravasation should be operated upon at once and the ruptured kidney either sutured or removed, depending upon the extent of the injury and the establishment of a second functionating kidney. Occasionally injury of the kidney may call for resection of one of the poles. A laceration through the extremity of the kidney in which the remainder of the kidney remains intact might be resected, although the cases in which resection is permissible must be very few. If infection should develop, operative intervention must be done as soon as recognized and the kidney and perirenal area drained. Gunshot or stab wounds of the kidney ordinarily need very little attention unless there is a severe injury and then enlarging the wound and packing may be all that is necessary. A striking exception of this, however, is a case which recently came under the service of my associate, Dr. F. E. Bunts. The bullet entered the left chest, ninth interspace, preaxillary line, passing through left kidney, as shown in cut (Fig. 151), carrying with it a piece of clothing, and lodged in the muscles of the back. Following this the patient had con-

Fig. 151.—Gunshot wound of kidney. Arrow shows course of bullet. Case of Dr. F. E. Bunts.

tinued bloody urine, temperature rising to $100\frac{2}{5}$°F. Nephrectomy was performed and the patient made a good recovery.

Injuries of the Ureter.—Most injuries of the ureter are those caused during operative procedure especially in the bony pelvis and generally in cases of extensive dissection for removal of adherent fibroids or carcinomata of the uterus. If recognized at the time, immediate repair should be made, either by anastomosis or transplantation. If the ureter is accidentally ligated and if with plain catgut, it will occasionally reopen spontaneously; but if ligated with silk, the ligature must be removed. This can generally be determined by the ureteral catheter locating the point of constriction. Anuria and pain in the back are generally symptoms which would suggest the possibility of an accident to the ureter. In the event that the anastomosis of the ureter cannot be successfully made or its permeability re-established by transplantation of other structures, the kidney on that side, providing there is a second functionating kidney, should be removed. The accidental causes, that is those not produced by operation, are generally severe traumatisms which produce injuries to the kidney; crushing injuries or punctures, as by stab or gunshot, although gunshot wounds of the ureter are extremely rare, even more so than of the kidney.

The operative technique for exposing the ureter would be the same as that considered under another chapter for operating for stone in the ureter.

Pyelography.—Probably in no field of medicine or surgery has the X-ray been of greater aid than in the diagnosis of obscure diseases of the genito-urinary tract, and the combination which has given us much information in diagnosis has been the ureteral catheter, opaque injections and the X-ray. In this way it has been possible to get a definite outline of this tract extending from the bladder to the calices of the kidney. Thus we can determine the course and size of the ureter, the deviation, stricture and kinks of this structure as well as the size of the pelvis of the kidney. It has also been found successful in determining tumor, calculus, beginning hydronephrosis, and in fact any malformation of the urinary tract. Braasch of the Mayo Clinic, who has perhaps had the largest experience with collargol, no longer employs this method in cases of large hydronephroses and in any case in which the pelvis cannot readily drain itself of the injected solution, nor does he use it in malignant tumors except when other means of diagnosis fail to identify the tumor (Braasch, quoted by Mason, J. Am. M. Ass., 1914, lxii, 839).

Method.—First pass röntgenographic catheters into one or if necessary both ureters. Do not inject the collargol, but let it slowly and steadily run into the renal pelvis. The majority of surgeons today prefer a solution of 5 to 10 per cent., depending upon the obesity of the patient. As soon as the patient complains of a feeling of fullness or slight pain, stop the injection at once and take the radiograph at full inspiration and full expiration. The safest method, according to J. W. Thomson Walker (Brit. J. Surg., 1914, ii, 155) of determining the quantity of collargol necessary, is carefully to watch the fall of fluid in a burette or glass vessel held not more than 6 or 8 in. above the kidney, and to cease the instant it stops flowing. It is very essential that the entire procedure be carried out without an anæsthetic because in this way the surgeon gets early warning and thus can avoid over-distention. As soon as the picture is taken, thoroughly drain the fluid from the pelvis of the kidney. This can be done by gentle pressure on the kidney or passing the ureteral catheter well up into the pelvis.

While received with much enthusiasm and applied very extensively it was soon found that it was not without danger. It has been shown both clinically and experimentally that collargol, which is the principal medium for injection, has penetrated the kidney substance, gone through into the blood-vessels and produced emboli at distant parts from the kidney, has caused necrotic areas in the kidneys and that in a few cases death has resulted from the injection. That this has been due in part to the technique there can be no doubt, but that it can occur in the most careful technique I think must be admitted. Very recently J. Edward Burns of the Buchanan Brady Urological Institute at Johns Hopkins Hospital has issued a preliminary report (J. Am. M. Ass., 1915, lxiv, 2126) on a new agent for pyelography, thorium, a neutral solution of thorium nitrate and sodium citrate. Thorium may be injected into the kidney, bladder, gastro-intestinal tract and other viscera for röntgenographic study. Burns claims it flows readily, can be voided immediately if used in the bladder, is perfectly clear to transmitted light, possessing a faint yellowish tinge in large volume, is perfectly clean, and still another big advantage over collargol is that it is much cheaper than many of the other preparations now in use.

Unless further experience shows some shortcomings which are not yet discernible the author believes that thorium will prove to be the safest and most easily used of any of the opaque substances thus far suggested for use in pyelography.

FUNCTION TESTS OF THE KIDNEY

It has been the hope of the profession for many years that some definite method could be worked out which would determine the functional capacity of the kidneys. This is of special interest to the surgeon and particularly the genito-urinary surgeon, who has been seeking some reliable data by which he might estimate what the kidney is capable of doing under certain circumstances.

Thus far no test has been equal to this demand. Many have been used and some give fairly accurately the condition of the kidney at the time the test is made, but do not give any definite idea of what the kidney is capable of doing under other circumstances as for instance, during certain inhalation anæsthetics, or after the removal of the other kidney. In all cases in which it is used the results must be weighed in connection with the clinical evidence present.

Of the various methods of estimating kidney function may be mentioned polyuria, methylene blue, indigo-carmine, phloridzin, rosanilin, determination of total non-protein nitrogen or urea, electrical conductivity, cryoscopy, sodium chlorid, potassium iodide, lactose, and the phenolsulphonephthalein tests. The chief objections to many of these tests are that they are not reliable, that their technique is too complicated, that the apparatus is expensive, and that the results are inaccurate.

The most satisfactory for all general purposes is the phenolsulphonephthalein. Although it is not absolutely infallible, it has many advantages: it is very simple, can be given in small doses, is eliminated in a very short time, its effect is non-toxic and non-irritating and it is excreted almost immediately entirely by the kidney. Another advantage is that it shows not only the absolute but also the relative value of each kidney.

Its bright color makes it very suitable for colorimetric methods. It is soluble in water, but especially in alcohol.

Technique.—Inject 1 cc. of the standardized solution, either intramuscularly or intravenously and note exact time; by the intramuscular method inject in the upper arm or thigh; intravenously in the vein of the forearm. We prefer the latter method, because it diminishes the time for collecting the urine, and the drug is eliminated much more rapidly. Insert the catheter so that no urine collects in the bladder. Some advise giving the patient a liter or two of water half an hour or an hour before the test, to avoid reflex inhibition, especially if the ureters

are catheterized; but others think this detail unnecessary. Collect the urine in a test-tube or specimen glass into which previously has been placed about 1 or 2 cc. of sodium hydroxid solution (25 per cent. solution). By doing this, the drug assumes a pinkish tinge which is much more easily detected than the golden yellow of the acid solution. Record the exact time of the first appearance of the drug and then collect the urine for two one-half-hour periods. If the drug is injected intramuscularly, two one-hour periods are required and the time of appearance is slightly longer (5 to 10 minutes); by the intravenous method, three to five minutes. If the ureters have been catheterized, remove the catheters one hour after the drug appears, if injected intramuscularly; and one-half hour, if given intravenously. Collect the urine in separate test-tubes. If the bladder has been catheterized, remove the catheter as soon as the drug appears. The amount collected is measured and diluted to 500 cc. if very little of the drug has been excreted, but if the color is very intense, dilute to 1000 cc. This can be approximated by inspection, after adding enough sodium hydroxid to bring out all the color. If after diluting to 500 cc. the color is still too intense for the highest reading on the colorimeter, the solution can then easily be further diluted to 1000 cc. (We have found the Hellige colorimeter very satisfactory.) After the dilution is properly made the solution is well shaken and a portion transferred to the small chamber of the colorimeter and the reading taken in a good natural light. If the specimen has been diluted to 1000 cc. the reading is divided by two as the standard solution contains only 3 mg. to the liter. If diluted to 500 cc. divide the reading by four. In normal cases the time of appearance is three to five minutes and the total amount between 70 and 80 per cent. It is always advisable to compare these results with a clinical history, a general physical examination, cystoscopy and the presence of pathological elements in the urine. In this way one can get a very accurate idea of the value of the kidneys. It is often advisable to use some other test with the phthalein in order to verify results. For this purpose the urea percentage and the diastase have been found valuable.

According to Geraghty (New York M. J., 1914, c, 312) urea estimations of the 24-hour output give information of but very little value. Patients with very low renal function and advanced renal disease frequently excrete larger quantities than those in good clinical condition and with comparatively good renal function.

He adds, "urea estimations of catheterized specimens give a very accurate idea of the relative amount of work done by each kidney."

Keyes and Stevens (Tr. Am. Urol. Ass., 1912, vi, 31) recommend "making two phenolsulphonephthalein tests, one with ureteral catheterization and one without. If an output of the drug is high during ureteral catheterization, clearly the second test is superfluous for estimating functional ability at this time."

The French have been using quite extensively a method rather recently devised, the so-called urea-secretory constant of Ambard. This author (Ambard) has expressed the constant relationship between the concentration of the urea in the blood and that in the urine in this way: "With a steady concentration of the urea in the urine the total secretion is directly proportional to the square of the urea-content in the serum." The normal constant was found to be from 0.06 to 0.08. Anything below 0.05 or above 0.075 would indicate abnormal function on this basis:

A constant of 0.085 shows a functional deficiency of 33 per cent.
A constant of 0.10 shows a functional deficiency of 51 per cent.
A constant of 0.12 shows a functional deficiency of 64 per cent.
A constant of 0.15 shows a functional deficiency of 78 per cent.
A constant of 0.30 shows a functional deficiency of 95 per cent.

SECTION XIII

THE BLADDER

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ANTISCRIPTUM

Even a cursory glance of the value of the healthy bladder in the economy of the urinary system will be sufficient to convey to our minds a vivid picture of the effects which its diseased conditions may entail on the integrity of the urinary tract.

At its lowest economic estimate a healthy bladder is one of the best assests of social man. At its highest, it is a life-preserving mechanism; only the latter aspect concerns us.

Speaking confidentially and without prejudice, the bladder is a siphon trap in an elaborate water carriage for the disposal of effete and dangerous products. It possesses all the requisites of a perfect trap—a smooth impervious surface, a generous flush of water from the two equidistant openings (the ureteric orifices), not an unduly pronounced ridge at the outlet, a large vertically placed waste pipe, all pipes being guarded by cunningly devised valves (sphincters) and flushed by a powerful automatic action of clearance (micturition). All these contrivances prove efficient barriers between the germ-laden air and the most vitally essential organs of the body, the kidneys.

Without belaboring the analogy, let us ask what practical axioms are written large upon this wonderful mechanism.

First.—The water sealing of the kidney is never forced; the ureters never conduct infection from the bladder to the kidney; if the kidneys become infected it is by way of the blood stream (hemic infection).

Second.—The integrity of the trap depends mainly on the nature of its water supply; thus, any toxic material descending from the kidneys may endanger its coating.

Third.—Any change in the "ridge" (prostatic elevation) causing a retention of toxic material in the trap must endanger its correct sanitation.

Fourth.—The water seal of the trap itself may be forced by way of the waste pipe (urethra); hence the surgeon is specially cautious not to enter it, instrumentally, and contaminate it.

Fifth.—If the trap is contaminated, it must be drained well. Hence the secret of successful bladder surgery is free drainage.

Anatomy.—Neither the clinician nor the surgeon concerns himself greatly about the pure anatomy of the organ. Only three points impress him as important: (*a*) the character and disposition of the peritoneal covering; (*b*) the position and character of the orifices; (*c*) that selective affinity for certain areas in the bladder which is shown by certain diseases.

(*a*) *The Character and Disposition of the Peritoneal Covering.*—The viscus, in the adult, which when empty is in shape like a triangularly folded dinner napkin, lies against and behind the pubic symphysis. Its apical or anteriorly placed angle serves for the insertion of the urachus, while the two basal or postero-lateral angles mark the entrance of the ureters into the bladder and the line of advance of the blood supply and nerve trunks to that organ. The peritoneum, which covers the triangle thus formed, is reflected in front on to the abdominal wall and behind on to the rectum or uterus. The surface thus constituted is aptly called the superior peritoneal face.

In surgery the peritoneum will be found loosely applied and separable toward the urachal angle but dense and undetachable as the ureteric corners are approached, a matter of importance in resections and incisions of this wall.

As the organ distends it rises and encroaches upon the abdomen. The surface which extends most under the pressure is the peritoneal face, and its anterior peritoneal reflection may be so lifted up by the distending bladder as to be as much as 2 to 2½ in. above the upper margin of the symphysis pubis, leaving the area below it (the cavity of Retzius) free from peritoneum and, therefore, open to the operator to reach the bladder without danger. In chronic retention, the bladder is readily felt above the pubis, and when a large quantity of urine has collected in it the height to which the viscus rises is generally gaged by marking the number of fingers' breadths above the line of the pubis. In proportion to the rise of the bladder in chronic retention so is the drop in the specific gravity of the urine, and there could be al-

most a definite formula constructed for estimation of this (for the specific gravity, not the presence of albumen, is the guide to the prognosis of a prostatic) were it not that in a small proportion of the cases the peritoneum is fixed to the upper line of the pubis and the bladder does not rise and bulge anteriorly against the abdominal wall but distends toward the spine. A posteriorly distending bladder with a fixed peritoneal apex is sufficiently important to require attention. The clinician is deceived by the tympanitic note of the intestine above the pubis in such instances and considers the bladder empty, whereas it may contain a large amount of urine; the operator too can easily open the peritoneum under such circumstances. This posteriorly filling bladder is generally present in large bilateral scrotal herniæ which drag the peritoneal covering down through the rings and cause it to form a tight strap on to the pubis.

(*b*) *The Position and Character of the Orifices of the Bladder.*—The three natural openings, the right and left ureteric and the urethral, are situated of necessity in the most firmly fixed area of the bladder, being placed at the corners of a thick triangular pad of fibromuscular tissue, the trigone, which marks the so-called "base" of the bladder.

The two ureteric orifices open at the basal angles of the trigone, while the urethral opening occupies the apex. The position of these openings relatively to each other is maintained in health but alters in disease. Thus, in 18 per cent. of chronic renal tuberculosis where there is much thickening and shortening of the corresponding ureter, the orifice on the diseased side is drawn outward away from its natural position and is then seen to be obviously "pulled out," an absolute indication for nephrectomy, while the warping of the urethral orifice by prostatic changes destroys the relation entirely.

A vertical line drawn through the center of the upright body passes through the urethral orifice and the first part of the urethra, a position obviously intended for efficient drainage, and an advantage interfered with only late in life in the male by the projection of the intravesical outgrowth of the enlarged prostate or the formation of a vaginal cystocele in the female.

Each orifice is controlled by efficient sphincters, the ureteric being supplemented by the obliquity of their course through the muscle coat of the bladder. So secure is this closure to reflux that it very rarely permits any water or any air introduced into the bladder to reach the renal pelvis. This sphincteric efficiency is sedulously preserved by any surgeon desirous of implanting the ureters into the intestine. Any

attempt to transplant the ureters without their orifices results merely in the renal pelvis becoming rapidly and lethally affected.

The cystoscopic aspect of the ureteric orifices in many cases leads to a knowledge of the conditions, healthy or otherwise; of the corresponding renal pelvis, so that ureteric meatoscopy is a study of the highest importance for the expert urologist.

The mucous membrane of the trigone is never detached in exfoliating cystitis, though the rest of the bladder may be stripped bare. Hence the mucous membrane of the orifices remains intact under conditions of great destruction. The trigone is too dense to be the primary site of a villous papilloma, though it may be encroached upon by an extension of the growth from the lateral boundaries. Although the lymphatics of the trigone are especially developed and drain along the sides of the rectum into the sacral glands situated between the bifurcated aorta, the surgeon who aims at removal of the cancerous bladder does not forget that there is a wealth of lymphatics throughout the mucous membrane of the viscus which drains into the groups of glands along the external iliac arteries.

The nerve supply of the trigone, and indeed of the bladder generally, is not well understood. It is still held with Courtade and Guyon, who observed the influences of nerve stimulation in the dog, that there is probably a differentiation between the spinal and sympathetic systems, the spinal evoking vesical contraction and the sympathetic governing the closure of the sphincter and causing the retention of the urine. The nerve areas for evoking the act of micturition and the areas of pain are clinically known. Thus, stimulation of three areas can evoke the complex act of micturition: first, the prostatic urethra and trigone; second, any section of the entire mucous membrane of the viscus; third, the muscular strata.

The areas for pain are also three. Painful stimulation of the trigone causes pain at the meatus urinarius. That of the deep layers of the ureteric orifice and adjacent lateral wall of the bladder is felt at the corresponding inguinal ring and along the corresponding side of the penis. The pain evoked by irritation of the mucous membrane of the upper two-thirds of the viscus is experienced suprapubically.

(*c*) *Selective Affinity of Disease for Certain Areas of the Bladder.*—It is a remarkable fact that certain areas of the bladder are especially liable to the incidence of disease. The determining factors do not here concern us greatly. For descriptive purposes, the bladder is considered to be partly filled and divided into zones (upper, middle and lower).

The lower zone, the true base of the bladder, comprises not only the trigone but the circumjacent areas. Each zone has a posterior or peritoneal face, an anterior and two laterals.

The Lower Zone.—The trigone, situated as it is at the embouchure of the kidneys and in direct continuity with a microbe-infested urethra, is extremely liable to primary trigonitis. The caustic discharges of the kidney, whether purely chemical (uric-phosphatic-oxaluric) or the basic chemical compounds (the leucomaines, true bacterial poisons, toxins, or the secondary toxic albumoses), are carried by the urine straight on to the trigone and induce a state of tumefaction, congestion and inflammation in proportion to the intensity of the poison. A similar result ensues upon the implication of the deep urethra by such poisons as the gonococcus, and other urethral poisons.

The ureteric orifices may be swollen, enlarged, ulcerated, changed in contour and even drawn out of position by inflammatory changes in their corresponding ureteric channels. Very rarely is the opening a "pin-hole orifice." When this occurs the center orifice and adjacent mucous membrane is ballooned out into a cyst-like formation, a condition similar to ballooning of the male prepuce.

The Periureteric Area.—The first effect of the descending stream of toxins of renal tuberculosis is the alteration in the corresponding ureteric orifice. Following rapidly on this is the scarlet scalding of the mucous membrane around it and the desquamation of the epithelium. This is specially marked toward the lateral aspect of the orifice, especially if the patient sleeps habitually on the side of the disease (toxin precipitate). Later the lower part of the superior peritoneal wall becomes similarly affected, but the actual trigone though swollen is never ulcerated, and never loses its mucous covering. If a single ulcer, the solitary chronic ulcer, forms spontaneously, that is, without instrumental causation, it is to the inner side of the ureteric orifice of the diseased kidney.

Villous papillomata never commence on the lip of the ureteric orifice but generally ⅛ to ½ in. behind and to the outer or inner side, some relation existing to the habitual sleep posture, if such be adopted by the patient. Reports that villous papillomata arise from the trigone are the result of insufficient care in examination; nor does a villous papilloma ever arise primarily from the anterior wall, though it may form there secondarily.

If a papilloma recurs, it does so in the same ureteric area whence it was cleanly removed, proving that the provocation is in the renal

stream of that side. From this, smaller papillomata spring up along the postero-inferior wall adjacent to the base of the trigone.

When definite cancerous growth appears in the bladder it is most often near one ureteric orifice, generally toward the middle line on the postero-inferior wall. This occurs in 60 per cent. of the cancer cases. The appearance of primary carcinoma of the apical zone is most unusual, 10 per cent. The middle zone is primarily affected in 30 per cent.

It will be remembered that there is a portion of the so-called "back of the bladder" uncovered by peritoneum, viz., the area situated between the peritoneum reflected onto the rectum or uterus and the densely tissued trigone. This is called the postero-inferior wall, or simply the posterior. It is also named the "unprotected space" or the "post-trigonal area." Along this wall occur most of those protrusions and herniæ and the so-called saccules of the bladder; the latter are especially found toward the inner side of the line of the ureters.

Stones occurring in persons of any age, but especially in those over 60, are formed in the post-trigonal depression.

ANOMALIES OF THE BLADDER

Exstrophy.—*Ectopia Vesicæ.*—This is a rare form of irregular development of the bladder which results in an absence of its anterior wall and its abdominal covering.

The postero-peritoneal wall of the bladder is seen projecting above the pubes as a dull purplish mass of mucous membrane, bulged forward by the small intestines which lie behind, and wet with the urine which constantly escapes from its ureters. The skin of the belly and legs is generally excoriated with eczema and malodorous in the extreme.

The sufferer, who is most often a male and has nearly always other coexisting developmental deficiencies, such as a guttered malformed penis (epispadias), retained testicles, bilateral inguinal hernia, non-union of pubic bones, is not only a social leper, but one which cannot be satisfactorily relieved. The life history of the exposed mucous membrane is punctuated by recurrent cystitis, phosphatic formations, erosions, ulcerations and finally, perhaps, malignant growth. It is essential to interfere surgically if possible. Plastic flap operations cannot supply a sphincter, and even if successful, prevent the cleansing of the ill-hewn cavity the surgeon has made. Bringing the ureters on to the loin and removing the bladder merely alters the site of the urinary exit

and fails from pyelonephritis, because the ureters are always dilated and prone to inflame. Drainage of both kidneys and cystectomy (Watson) offers the same dangers. Probably Maydl's operation, of diverting the urine into the rectum by transplanting the trigone and at the same time sedulously preserving the integrity of the ureteric orifices, is the most surgical and most successful way of treating this pitiful but disgusting condition. Even then much discomfort, even incontinence, may be experienced from the liquid stools, and the surgeon is driven by the rectal pain to perform bilateral nephrostomy.

Pouching, Hernia, Diverticulum of the Bladder.—Any extra and prolonged stress, whether prenatal or otherwise, upon the bladder wall causes part of its constituent tissues to give way.

The wall may be merely bulged or pouched as occurs post-trigonally in stricture of the urethra or enlarged prostate or the rarer forms of "stammering bladder," or the mucous membrane may be forced between fasciculi into small pockets or depressions (herniæ) which, if they increase in size, become veritable flask-shaped pockets or diverticula communicating with the bladder by a narrow neck.

The favorite area for these diverticula is the periureteric. The symptoms are masked by those of the stress diseases which evoke them, until changes occur in the lining membrane of their wall, such as inflammation, stress, erosion of the orifice, formation of stone in their cavities, papillomata or epithelioma. The diagnosis rests with the cystoscope or actual visual examination through a suprapubic wound. The smaller diverticula which drain easily into the main cavity of the bladder need only a freed urethral outlet, but the larger demand free removal or, if they harbor carcinoma, cystectomy.

Foreign Bodies in the Bladder.—Quite a startling array of foreign bodies have been found in the human bladder introduced there by the ingenuity, carelessness or clumsiness of the prurient of both sexes, the female being the greater offender; or foreign bodies such as pins, ligature knots after uterine operations, scraps of bone from necrosed areas and bullets gradually ulcerate their way from other places into the bladder. Any form of foreign body sooner or later sets up cystitis, becomes encrusted with phosphatic material and forms stone. It is, therefore, of the greatest importance to obtain an early removal of the offending body. Since the introduction of the X-ray and the cystoscope the veracity of the patient is not of importance and diagnosis follows readily upon the first signals of distress.

The surgeon who is expert with his lithotrite will be able without

difficulty to seize the end of any catheter, bougie or rod-like body and withdraw it. A little difficulty may be encountered in dealing with wax tapers, for they float, and every movement of the lithotrite in the bladder disturbs the orientation. Such are best dealt with by almost emptying the bladder. Slate pencils, glass rods, hair pins, hat pins, if they are found unencrusted, may be easily removed in the female by passing Kelly's urethroscope over the end under control of the eye, while the patient is in the Trendelenberg posture. The same maneuver is brilliant in the case of stitches, ulcerating through but not yet separated from the bladder wall.

When foreign bodies have remained long in the bladder and have induced severe cystitis they must be dealt with by suprapubic cystotomy because any rough handling of a lithotrite or exhaustion bulb may cause extraperitoneal rupture of the walls and consequent death.

The only foreign body with which the surgeon anticipates difficulty in dealing is hair. This always originates from a pelvic dermoid. When hair is encountered in the bladder full permission must be obtained and provision made for abdominal section, removal of the dermoid sac and repair of the ulcerated opening in the bladder through which the hair has escaped.

Foreign bodies, such as pieces of the enlarged prostate, gauze, swabs, or tubes left by the inexpert surgeon in the bladder after suprapubic cystotomy, call urgent attention to their presence by an unhealed operation wound, the continued cystitis, the odor of the discharge and the evening rise of temperature but the culpable carelessness is easily remedied by reopening the wound.

Accidents to the Bladder.—*Rupture.*—The surgeon nowadays is rarely responsible for rupture of the bladder in litholapaxy, because those who are inexpert content themselves with suprapubic cystotomy. When it does occur it is an extraperitoneal rupture and generally takes place at the lower part of the posterior wall, at or just where the stone has lodged and softened the textures. An attempt may be made to drain by perineal cystotomy if the rupture is of limited extent, but usually the patient dies of septic suppression before the character of the accident is recognized and after death the entire tract is usually found in a state of chronic septic inflammation.

It is problematical as to whether spontaneous rupture ever occurs, but traumatic rupture is not an infrequent accident and may be severe enough to test the acumen and skill of the best clinician and surgeon. Consequent upon some known and obvious injury to the lower trunk,

such as a crushing force to the pelvis, a fall from a height, or even a fall of earth on the back when the man is in a stooping posture, symptoms of severe abdominal injury and shock ensue. Under such conditions it is the rule to suspect the bladder, and if it is known that the organ was not empty at the time of the accident and the patient cannot urinate or can pass only a little bloody urine, it is surgically wise to investigate its condition as soon as possible and to operate coincidentally. Despite experimental findings, practical knowledge of cases of rupture shows that the tissues, peritoneal or extraperitoneal, will not tolerate urine, sterile or not, and hesitation or cowardice on the part of the surgeon is paid for by the death of the patient. There should be no long interval between the examination which reveals rupture and the operation which repairs the same.

The bladder is ruptured most often through the peritoneal face, 80 per cent. (Watson), extraperitoneally 20 per cent. The first step is to ascertain if the bladder is ruptured. A fully asepticized catheter is passed. In intraperitoneal rupture only a little blood-stained urine may come through it, but in extraperitoneal a certain quantity of blood and urine is generally evacuated. The presence of blood is the clue to injury of some form and the determining reason for further examination. In such cases the cystoscope is of no value and reliance must be placed on the use of sterile water, the amount run in being noted. If the same amount fails to return and repeated attempts are fruitless and there is no palpable rising of the bladder above the pubes as would occur if it was distending normally, it is better to operate *at once* suprapubically, opening the peritoneum later so as to test both areas, the cavity of Retzius and the peritoneum.

Expectant treatment is practically fatal (96 per cent., Mitchell) in both forms of rupture, though the end is prolonged in extraperitoneal forms. An early operation yields fair results (62 per cent. mortality) especially if it is performed within 12 hours.

INFLAMMATION OF THE BLADDER

(Ureteric Meatitis, Trigonitis, Cystitis)

As inflammation of the bladder is the "be-all and end-all" of every vesical disease and as the symptoms it evokes mask or confuse those which are characteristic of other affections of the viscus, it is important to be familiar with its clinical picture. There are many different forms, many grades and many phases of cystitis, but all may be strictly limited

in extent as in trigonitis, or quite general as in true cystitis. The cause is always microbic and the symptoms, which do not vary except in intensity, are always produced by the scalding, burning, or erosion of toxin-laden urine, or toxin-charged urine.

The bacteria most often encountered are of the coliform group (Bacillus coli communis); associated with it may be the staphylococcus, streptococcus, or even the proteus of Hauser. Cystitis, however, is not merely the meeting of a bladder and a microbe; bacteriuria may exist without any symptom of cystitis. Before the appearance of cystitis certain conditions must exist depreciating the vitality of the bladder or exalting the virulence of the microbe. These conditions are mainly those of congestion of the bladder wall, or retention of urine (stagnation). The microbes reach the bladder most often by way of the ureter from the kidney; others either enter, or are pushed into, the viscus from the urethra. They probably also invade it, by way of the circulation, from adjacent foci of inflammation. Here, though it is a digression, should be mentioned the rarity of catheterization-inoculation. In preaseptic days some damage was undoubtedly wrought by dirty instruments, but the aseptic catheter of today lights up cystitis just as frequently. This it does, not by conveying a microbe, but by traumatizing a congested or stagnant bladder, or by reducing wall tension and thus attracting thither bacilli which may be "resting" in prevesical or periurethral tissues. Whether such bacilli are absorbed and return via the reno-uretic stream or pass directly through the vesical circulation into the bladder is a matter not determined, but this is a golden truth of value to the clinician and to be impressed upon the public, "*careful aseptic catheterization in cases favorable for microbic fulmination may and does induce intractable bacteriuria and cystitis*" (cf. atony of bladder).

Symptomatology.—Three characteristic symptoms are present in cystitis; frequency of micturition, pain in the act, and puriform urine. Without these signs the clinician has been taught that the term is a misnomer. But the expert cystoscopist knows otherwise; he examines many cases in which the urine is clear and sterile and yet the bladder is marked with small areas of unhealed cystitis, patchy cystitis, the only symptom being undue frequency of urination. The nature of the onset is so great a guide in prognosis that the clinician never neglects to ascertain it.

If the attack is very acute and the chemico-toxin scalding has been of great severity, the desire and effort to urinate may be so frequent as almost to be continuous, even to constituting false incontinence every

5 to 15 minutes is the rule. The scalding pain at the bladder neck and along the urethra before the act is severe, but the pain at the completion of the act at the meatus is often an agony and is accompanied by such straining to avoid the last drops as to induce widespread spasm and radiating pains. Bright blood may be forced out or squeezed out of the congested neck of the bladder at the end of the act (terminal hematuria), or the entire secretion, in cases of less severity, may be quite bloody (hemorrhagic cystitis). Rectal examination or suprapubic pressure may be quite intolerable. As the acuteness of the attack passes off, and this generally occurs within the week, the condition becomes what is termed subacute and finally chronic. The frequency of urination diminishes, the pain is subdued, but the pus remains; indeed it is increased, becoming glairy muco-pus, the reaction and smell becoming alkaline. If we except cantharidism, a very acute onset suggests a grave and a dangerous poisoning while the subacute or slight onsets are noted in the less virulent microbic infections.

Varieties of Cystitis.—Certain forms of cystitis merit a passing notice, others are phases merely and their nomenclature is due to the especial virulence of the microbe or to the area in which its destructive activity is exercised.

Gonorrhœal cystitis which is said to be the commonest form encountered, does not exist. What is noticed is either a urethro-prostatitis or an instrumental cystitis and in both the peccant potent microbe is not a gonococcus, but is of the strepto-bacillary variety, introduced or appearing during the treatment of the complaint.

Microbic Nephropyelo Trigonitis.—All hemic microbic infections of the kidney produce a toxin-laden urine which is capable of inducing a swelling of the trigone, a trigonitis, the symptoms of which are erroneously deemed to be those of cystitis and the case is treated on this diagnosis, while the true source of the poisoning, the kidney, remains unnoticed, undetected and untreated. Hence it is usual to call such cases of trigonitis false cystitis. Some degree of true cystitis, however, is often present in the severer forms where there is a mixed infection (B. coli and strepto-bacillary) because the caustic influence of the toxin extends beyond the trigone; the resultant changes spread over the entire viscus and one especial microbe which affects the kidney, becomes trigonically endemic and therefore has become a specific clinical entity.

Bacillus coli nephropyelo cystitis is a very common complaint especially in the winter months and has well-defined clinical features.

After a brief prodromal phase of malaise there is a sudden rigor, the severity of which marks the grade of infection. Coincidently, or even a few hours prior to the rigor, there is a frequency of urination and a scalding during the act, the urine being puriform and containing the Bacillus coli communis. The kidney is generally tender to the touch, the grade of tenderness marking the degree of cortical infection. Later the opposite kidney may be similarly affected, but in milder cases the entire trouble seems confined to one kidney. Cystoscopy shows small patches of dull red extravasation and exudation on the posterior wall of the bladder, swollen but not eroded ureteric orifices and punctate hemorrhages of a tumid trigone.

Treatment.—In severe cases the kidney which is supplying the microbic toxin may require operative treatment. With appropriate treatment the bladder symptoms subside, though they may recrudesce on chills, worry or injudicious diet. These cases are particularly amenable to autogenous vaccines, commencing with small doses (two to five millions), combined with urinary antiseptics such as the urotropine group.

The Bacillus coli cystitis, the true cystitis of this microbic infection, is of purely local infection, the microbe attacking some previously weakened area such as a cystocele in the female or a post-trigonal pouching in enlarged prostate, or in stricture of the urethra. It is a much more difficult matter to treat because it is usually complicated with the incidence of other organisms, streptococcus, staphylococcus, proteus. The first step is to ascertain the source of the disease. Diagnosis is based on symptomatology but mainly on cystoscopy and ureteric catheterization, practised when the acute symptoms have subsided.

The frequency of urination and the pain is much more pronounced and less under control of treatment. The B. coli and pus are always to be found in the urine. It is a grave question whether a true and severe B. coli cystitis is ever cured. When the focus of the infection can be entirely removed as by prostatectomy, or seminal vesiculectomy, a cure may be hoped for, but the bacillary penetration of the bladder wall is often so marked a feature in cases where the bladder wall has been greatly exposed to the poison that the viscus rarely if ever recovers its normal resilience and expulsive power. The patients may in time become tolerant, hold urine for two or more hours, have but little discomfort, but the urine never clears and there is always a tendency to exacerbation on slight causes.

Treatment.—In this class autogenous vaccines are of but little use. Vesical irrigation carried out faithfully with the silver and mercury salts is of value; combined with this, ionization may be used. Medical treatment with the various remedies used for so-called chronic cystitis is of little permanent value.

Tuberculous Cystitis.—Although this is only one part of a widespread affection of the urinary tract, it is always the most clamant, distressing and uncontrollable feature of the disease. It is, therefore, necessary to raise it for the nonce to the rank of a surgical entity and refer to it somewhat in detail.

Tuberculosis of the bladder is never a primary affection. In the female and in a fair proportion of males it arises from a direct infection from a primary tuberculous kidney; it is a water-borne disease. As the renal disease is unilateral in 80 per cent. of the early cases, it follows that the lesion in the bladder should also be unilateral at the very commencement of the infection. When tubercle bacilli appear in pure culture, and this occurs in cases of unmixed infection, the disease is generally mild, the area is limited and the prognosis good. The diffusion, the grade of severity and the gravity of the prognosis depends not so much on the tubercle bacillus as on those pyogenic microörganisms which sensibly aggravate the local condition.

Cystoscopically the ureteric orifice will be the first to show alteration in health; its lips are scalded, its shape is warped and irregular, and perhaps its position is displaced (18 per cent.). If the renal tubercle has become recently inflamed by an admixture of flora, the orifice may be bullous. Toward that side upon which the patient sleeps, if a sleep posture is habitually used, there will be bright red scaldings and epithelial peelings. Such red patches of surface change are only superficial, they may be noticed across the posterior wall and even to the outer side of the other ureteric orifice; but this latter opening retains its healthy appearance until later stages. Should neither ureteric orifice show signs of ureteric disease, as occurs in a small proportion of the cases, the ureteric catheter must be used to determine the health of each kidney.

If favorable conditions obtain, the scalded or infiltrated mucous membrane may heal and the side of the bladder be covered with arcuate white scars which generally radiate from the diseased ureteric orifice, but the process usually extends laterally and deeply. The exudation may soften and deep ulcerations result. Little by little, in the worst cases, the mucous membrane is exfoliated until a small denuded inelastic

bladder remains, its capacity being about an ounce to two ounces at the most.

The removal of the kidney, which is the site of the original focus, generally causes cicatrization in time and a final return to healthy conditions, but even this depends on the state of the bladder prior to the nephrectomy.

Symptomatology.—The incidence of the mild local disease in the bladder is at once signaled by frequency of urination, at first in the day and then at night. This is followed in a few days by pain at the meatus after urination and soon after a slight terminal hematuria may be noticed, the distinguishing difference between this and calculus being the sudden onset of the frequency, the disturbance at night, the pale murky urine which contains pus and tubercle bacillus and is always of a lowered specific gravity when the kidney is the origin of the infection. It may be that renal pain has not been noticed. This is no evidence of immunity of that organ, as a large proportion of cases of renal tubercle are latent, the alarm signal being sounded by the distressed bladder and not by the diseased kidney. The acute onset of bladder symptoms is usually due to the sudden discharge of a renal tuberculous focus, cyst, or cortical abscess.

Should the disease be more acute or progressive and have extended across the posterior wall, the symptoms of pain are of a different character. It is then experienced before micturition and is suprapubic; in fact, the suprapubic pain demands relief by micturition and if the desire is not promptly complied with straining follows, with increased frequency and bright hematuria.

Although up to now all the classical symptoms of cystitis are present, the greater part of the bladder, cystoscopically, may be healthy and brilliant in sheen and the conditions may remain so for one or two years or more, but there is always a further breakdown. Sudden aggravation of all symptoms points to the intercurrence of some fresh pyogenic organism and true cystitis of the bladder supervenes, the tuberculous patches becoming inflamed, softened and eroded.

The frequency, pain, straining and often the power of expulsion is now extreme, the sleep is so broken that one wonders how the patient can live. According to the depth of the ulceration so is the local pain which is increased by jarring or oscillation or by sleeping on the side affected. Any quick movement is carefully avoided. Incontinence may supervene and when it does the patient's life is prolonged and comparative peace and freedom from pain are assured.

Intercurrent Attacks of Cystitis in Tuberculous Kidneys.—One of the puzzling phases of urinary tuberculosis was the fact that the cystitis was recurrent, the patient being practically normal, except for tuberculous pyuria, in the between time. Cystoscopically these cases are examples of ureteric meatitis, the ureter being intermittently inflamed by fresh deposits of tubercle in the cortex breaking down, the resulting renal débris and toxins floating down the ureter with the urine. Directly the new focus in the kidney pelvis has disintegrated and the toxins of destruction and tubercle have ceased to irritate the ureteric orifice and trigone, the patient is again restored to health. Such cases repay nephrectomy.

Treatment of Tuberculous Cystitis.—In the whole range of urological surgery there is no disease in which the patient is more severely penalized by want of judgment, care and gentleness than in tuberculous cystitis. A wise well-balanced clinician (remembering that most of the cases originate in renal tuberculosis and that it is impossible to adequately gage renal destruction) will be guided in his decision as to nephrectomy by:

(*a*) The character of the ureteric orifice. If it is retracted, or if the ureter is thickened, or if the orifice and the surrounding mucosa are greatly scalded, he decides on nephrectomy.

(*b*) The character of mixed infections which raise a suspicion of uncontrollable renal destruction.

(*c*) The character of the onset symptoms, whether they are vesical or whether they are renal.

If the onset is distinctly *vesical* and *gradual*, the use of tuberculin (new T. R.) in small doses $\frac{1}{5000}$ mg. injected weekly, will relieve in the early stages.[1] Now and again, when the primary infection of the kidney is slight and there are no kidney symptoms, this method can be used with benefit and may apparently *cure* (5 to 10 years). It is not a cure and should not be termed one.

If, however, the onset symptoms are purely renal and not vesical and there is severe renal ache, especially true renal colic, tuberculin must *not* be used, for it increases the swelling of the mucous membrane of the ureter,[2] and tends still further to block the outlet of the damaged kidney. It acts locally on the kidney tubercle, and increases greatly the destructive process.

Irrigation of the Bladder.—If the disease has come on very acutely and the frequency of urination is very severe (every 10 or 30 minutes),

[1] Author: Ulceration of Bladder, 1900, p. 44.
[2] Author: Med. Soc. Trans., 1905, p. 242.

washing away the acrid toxins, by irrigating the bladder *aseptically* for a week, gives the greatest relief. Nothing but a weak boric solution is necessary.

Routine vesical irrigation, after the first acute onset, is useless; it may even be dangerous, for the bacilli coli or proteus may appear, become hematogenously carried to both kidneys and increase the tuberculous destruction in the one, or depreciate the vitality of the other. It is a fair comment on wrong diagnosis and injudicious bladder treatment to remark that the patients who show the best end-results are those whose onset symptoms are kidney pain, and who, therefore, come under the surgeon early and have nephrectomy performed, without the well-meant, but makeshift, Fabian policy of treatment by vesical irrigation. Weekly injections under chloroform or morphia, of carbolic acid 5 per cent. (Rovsing) or mercuric chloride are stated to be beneficial in procuring healing. It must be remembered that after nephrectomy the bladder heals, provided that the surgeon has been a surgeon, that he has removed the kidney cleanly without opening it and fouling its bed, without nicking the pelvis and allowing its drainings to contaminate the large perirenal wound. If the wound remains sluggish two conditions inevitably result: pain in the opposite kidney, wound toxin nephritis, increased irritation of the bladder wound, toxin cystitis.

Attempts have been made in grossly neglected cases to relieve those who are not incontinent by opening the bladder and scraping. It is unsurgical and merely courts disaster. Its only result is still further to contract the bladder and leave an open, unhealable fistula. The disease is often too advanced and the patient too debilitated, when the surgeon is permitted to interfere, to offer much hope of relief by placing the ureteric orifice in the bowel, but one or both ureters can be placed on the loin and drained into a bag; the patient is then in peace and comparative comfort. The prognosis varies according to whether the kidney is involved or not. Patients have lived with marked genito-urinary tuberculosis for as long as 30 years, but then the disease was confined to the lower urinary tract and fibroid and calcareous changes in the deposits were a marked feature in the case.

Medical Treatment.—The exhibition of sandal oil (♏x. in capsule after meals) often acts like a charm. If the vesical trouble has proceeded to ulceration and the pain at the meatus is not only constant but knife-like on jarring the body, only opium will help; it is best given by the

bowel or with *Euchsine in pill* (gr. ¼ āā). Any of the tisanes, pareira, buchu, triticum, uva ursi, collinsonia, stigmata maydis, assist.

General Lines for the Treatment of Cystitis.—The clinician concerns himself chiefly with the determination of three essential points: (*a*) the nature of the predominant microbe, (*b*) its source, (*c*) the extent and depth of its action.

(*a*) Seeing that the coliform and tubercle bacilli and gonococcus flourish in acid urine and the rest in alkaline, a guess can be hazarded after using test paper and glancing at the urine as to what microbe may be present. Very few tubercle bacilli will produce a large amount of pus but it takes many coliform bacilli to produce even a little; besides, the coliform bacillus has often a characteristic fishy smell and the urine when shaken has a shot-silk appearance. The microscopist detects the difference at once; if not, cultural and inoculational investigations are needed.

(*b*) The source of tubercle bacillus is nearly always renal. Coliform bacilli also are most frequently of renal origin, although female patients with cystocele and men with enlarged pros ate, old stricture of the urethra, or even long standing posterior urethritis are likely to have primary coliform infection of the bladder. It is the rule to suspect coli cystitis after parturition to be pyelitic. But the cystoscope in expert hands settles this and the next difficulty.

(*c*) Some realization of the extent and depth of the action of the bacillary poison is of the greatest value in prognosis and treatment. Both coli and tubercle, if they are reinforced by other organisms like the streptobacillary group and staphylococcus or proteus, tend to invade the submucous layer and even to penetrate the wall intramuscularly. In both instances the final stage of a grave infection is a contracted irritable painful bladder, either the muscle areas being in a state of irregular fibrosis, or the mucous membrane being irregularly scarred and therefore unyielding. The tendency under these conditions is to contraction often uncontrollable, and slowly progressive.

Probably every form of cystitis, if we eliminate the idiosyncrasy of the patient, has its particular specific. Thus the cystitis or pyelitis of uratic irritation requires boric acid. That due to phosphatic irritation is best treated by helmitol. That which is due to fæcal irritation (vesico-intestinal fistula) is greatly helped by methylene blue and sandal oil. Most forms of swelling of the mucous membrane are relieved by sandal oil; tubercle is especially under its influence, if there is no mixed infection.

The old mixture of bicarbonate of potash, hyoscyamin and buchu, or one of the many tisanes, is a valuable remedy as a stop gap.

Lavage has a province of its own. In woman it has less restriction than in man. It is of most use when there is muco-pus. It must be remembered that boric acid, silver salts and mercury salts are the most valuable applications. Any mercury salt is very penetrating and painful and must be used well diluted.

TUMORS OF THE BLADDER

Since the introduction of the cystoscope the clinical outlines of this disease in all its forms have become sharply defined; the clinician does not concern himself with the abundant but unsatisfying nomenclature of the pathologist, but directs his attention to three problems. Is there a tumor of the bladder? Is it benign or malignant? Is it curable by operation or not?

All these questions are answered, and can only be answered, by expert cystoscopy.

Broadly speaking, the cystoscopist will encounter two well-marked varieties of vesical tumors, the villus-covered and the bald. Those clothed with villous processes may be benign or they may be malignant, but the smooth-surfaced groups are always malignant, more especially if they occur after the age of 45. Nor is such a division devoid of practical utility, for it will be found that attempts at successful operative removal can only be made on those which are at first localized on the surface, that is, on those covered by villous processes.

Clinically and cystoscopically, then, tumors may be considered under three heads:

A. The benign villus-covered growth.

B. The malignant villus-covered growth.

C. The bald, malignant growth.

A. **The Benign Villus-covered Growth.**—The villous papilloma is a tumor which consists of a "core" covered with "villous" processes.

The processes or "villi," which clothe the surface, are often of extreme tenuity and resemble chorionic villi. The more luxuriant, more translucent and longer villi appear to be younger in age than the stunted or whitened villi, so that when multiple papillomata are seen, it is probable that the delicate and leafy villous groups are secondary seedings or implantations. Such are especially noticed over the urethral orifice on the anterior wall and along the posterior wall; the

primary growths are always at or near the ureteric orifice. Those villi which are caked, or powdered with phosphatic débris, have been inflamed and are necrotic; probably they have bled. As a rule, the benign villous tumor is pedunculated either finely or broadly. If the pedicle is very long, it allows the tumor to cork the urethral orifice, impede the stream and damage the kidney (8 per cent.). Papillomata usually arise to the outer side of the ureteric orifice (90 per cent.) and their position indicates two conditions, a cause and an effect of their presence, the cause being due to irritating urine from the corresponding kidney, and the effect being some backward dilatation of the corresponding ureter (80 per cent.), which is slight perhaps but sensible.

B. **Villus-covered Malignant Tumor.**—(*Papilliferous carcinoma*).—This is an intermediate group between the benign surface villous papilloma and the bald malignant infiltrating growth.

The tumor is covered with villi which may perhaps be more stunted and succulent in aspect, though it is often impossible to state definitely on visual grounds that a villus-covered growth is malignant or not. There is, however, no hesitation when the operator's finger examines the base, because the hardness, characteristic of malignancy, is detected at once.

The tumors are certainly more luxuriant, more often multiple, more scattered, more sessile than the benign papillomata, though they affect the same areas in the bladder, viz., the ureteric and peritrigonal; they are at first indolent; any cystitis or any half-hearted attempt to remove them awakens their activity, the basal tissues thicken, and infiltration proceeds apace.

C. **The Bald Malignant Growth.**—When epithelioma attacks the mucous membrane of the bladder, its energy is generally expended in one of two directions: (*a*) Either it rapidly penetrates the wall of the bladder, infiltrating it early and deeply, or, (*b*) its activity is on the surface, being displayed in tumor formation. When this is so, it is not until a later period that the deeper structures of the wall are implicated by extensive downgrowth.

(*a*) *The Infiltrating Group.*—The infiltrating group is the more common (84 per cent. of hard carcinoma). The invasion can generally be detected at an early stage of the disease per rectum or per vaginam because it arises low down on the posterior wall. It can be digitally diagnosed in 50 per cent. before the end of the first year and in 82 per cent. before the end of the second year. The discovery of the hard cake-like condition settles the diagnosis and prohibits cystoscopy; but

supposing the cystoscopy was called for before cystitis and before the infiltration was detectable, the following visual appearances can be relied on as characteristics of the disorder.

Near one or the other ureter, often encroaching on the trigone and creeping over its posterior edge, will be seen a *bald*, irregular, rolled-edge growth of a dull red color, looking like an epitheliomatous tumor on the tongue. Cyst-like bodies guard the edges or stand out in crops from the surface. Once the surface has ulcerated, and it does so *very early* in its clinical life, its aspect changes. The color becomes more or less white in parts; thin films of mucus enwrap it; lizard-skin cracks radiate here and there across the lobules. These cracks become filled with white phosphate of lime, and even a lobule or a group of lobules may be covered and concealed by a thick concave crust of grayish lime phosphate. This crust being loosened by ulcerative change falls onto the post-trigonal area, is swept away with the urine and passed. It should be recognized as an ulcer crust.

(*b*) *The Tumor-forming Bald Epithelioma* (16 per cent.)—The softer form of tumor formed by bald epithelioma is also more often found arising from the posterior wall behind the ureteric line. It is generally subsessile, but may be thickly pedicled (3 per cent.). Visually it appears as a rounded mass, which varies in size from that of a walnut to that of a tangerine orange. Its color is white or grayish white; generally here and there are cracks like those seen in dried putty; fibers, or clumps of fibers, hang from the surface, the result of maceration and necrosis, but there are no villous processes. The mucous membrane around is always red, gelatinous, and mucus-smeared. It is often possible to remove such a growth by "morcellement," the tumor tearing like a turnip with very little bleeding; but nearly always a thin base formed by the submucous and muscle layer glued together is left, from which the growth quickly reconstructs.

Symptomatology.—The symptoms of vesical tumor are as characteristic as the growth which causes their appearance.

(*a*) Every soft growth, whether it be benign villous (84 per cent.), villus-covered carcinoma (75 per cent.), or bald carcinoma (60 per cent.), reveals its presence for the most part by a terminal hematuria which (contrary to that seen in cystitis) is painless. This is called "symptomless" hematuria. The patient is astonished to see blood at the end of a clear stream. If the patient is in the dark or unobservant, the blood will be noticed mixed with the urine in the utensil or staining the garments. The percentage of cases in which this symptomless hem-

orrhage appears as an onset symptom dwindles as the tumors become tougher; 84, 75, 60 are their percentages.

The urine, however, between the attacks of bleeding is at first normal in every constituent, unless the harder form of growth is present, when a decided trace of albumen from "serum" sweating will be detected.

The softer tumors have prolonged hematurial stages; the benign villous may thus betray its presence for years; the softer malignant tumors average three years. It is noticeable that in proportion as the tumors become denser, so the hemorrhages are sooner followed by symptoms of cystitis.

The symptoms of cystitis in benign villous growth and villus-covered carcinoma are often accentuated by phosphatic caps which form on the necrotic villi and, eroding off, become little jagged calculi. The severity of the symptoms mainly depends in these cases on the extent to which the bladder distends with the growing mass of tumor.

The sufferings in the cystitis stage of the soft carcinomata are severe, often inexpressible. They are in direct relation to the diffusion of the growth. The miseries of cystitis, of retention, of renal obstruction, of growth attacking the pelvic organs, all combine to form a picture of unrelievable agony. When the growth is very soft and rapid some suffer comparatively little. Even though the bladder becomes filled with soft growth, and the rectum invaded and semi-occluded, yet pain is, in rare instances, quite under the control of morphia. It would seem as if the sufferings in some cases terminated as soon as the nervous and muscular elements of the bladder are transformed into soft carcinomatous growth.

Incontinency of urine is favorable, in that when the restless energy of the bladder neck ceases, the local sufferings diminish.

(*b*) *The hard and infiltrating groups* have a different complexus of onset symptoms. There may be a brief hematurial stage, but the stage of cystitis is entered within a few weeks. Ominous signs of infiltration appear in the form of frequency of urination and pain. Before the hematurial stage is well over, frequency of micturition denotes that an area of the bladder surface is altered and "stiff," and that it thus resents the stretching of ordinary distention. There will always be some penile pain after urination, but this is not characteristic. It is the "constant" pain in other regions, which is independent of micturition, which affords an important clue, both in diagnosis and prognosis.

It will be frequently observed that in men the pain is at first *one-sided*—one side of the suprapubic region, the inner side of one thigh, the

penis, one groin, one hip, one loin. In women it is frequently suprapubic.

These unilateral pains point to the position of the growth; thus, for example, right- or left-sided suprapubic pain indicates growth starting in the corresponding ureteric area. When renal pain is superadded, it may be correctly surmised that the growth is extending around the ureteric orifice and adjacent channel.

Inner thigh pain and pain in the obturator nerve area demonstrates that invasion is progressing toward the prostatic capsule, and affecting the lymphatic glands near or at the point where the obturator nerve leaves the lumbar plexus; that the growth has, in fact, a trigonal or a circumtrigonal situation. With this is associated, either coincidentally or consecutively, a groin pain, from lymphatic extension to this region.

Sciatic pains point to a secondary deposit in the lymphatic chains around the sacro-sciatic foramina compressing the plexus.

These pains indicate secondary deposits and are irrespective of those other pains, such as perineal and urethral, which are due to direct action of the growth on the neck of the bladder.

It is important to note how frequently the patient is forced into the "painful" stage by sounding, or even by the use of a catheter employed merely to test for residual urine. Very rarely indeed does instrumentation, except cystoscopy, afford the slightest indication of the nature of the disease. If infiltration can be detected per rectum, it is held that the employment of stiff instruments is not only unsurgical, but evidence of culpable carelessness.

Points in Differential Diagnosis.—There are other causes for symptomless hematuria which must be considered. They are those in which the urine is passed intimately mixed with blood, and are mainly of renal origin; all are, however, excluded on cystoscopic grounds.

Thus, if latent renal carcinoma bleeds freely into the bladder or if a sharp hematuria emanates from a granular kidney or an angioma of a renal papilla, the source of the bleeding can at once be detected by the cystoscope.

The hematuria of the enlarged prostate is more difficult to determine, but even here a clinical and tactile examination may lead to a direct suspicion of the origin of the blood.

Broad Outlines of Treatment of Vesical Growth.—This is quite well defined, being either palliative or operative.

Palliative.—The initial stages of hematuria generally cease spontaneously. The later are controllable only by removing the growth, if it is

benign, or the face of the growth if it is carcinomatous. Villel or Contrexéville water in the early morning will check the early bleeding of a benign papilloma for over six months. For every patient there is probably a specific hemostatic. The difficulty is to find it. The order in merit is ergot, turpentine, gallic acid, aluminate of iron mixed with a laxative.

It is unwise to use lavage unless clot retention ensues, when either weak silver nitrate solution or mercuric chloride, 1 in 10,000, should be employed after the clot has been evacuated through a large-eyed catheter, assisted by the suction action of a syringe.

In the later stages the use of sedatives is imperiously demanded, or the ureter stream may be diverted in the harder forms by bilateral ureterostomy, in the softer forms by suprapubic drainage.

Operative.—Villous papillomata can be slowly eradicated by repeated fulgurations (bipolar current) applied through a ureter cystoscope, but the general surgeon had better be content with cystotomy. Villous papillomata, whether benign or malignant, can be easily removed suprapubically through a caisson (a speculum). There is no necessity to open the bladder through the peritoneum. It merely depreciates the bladder and does not render the removal of the tumor any easier or more thorough.

Carcinoma of the upper half of the bladder can be safely and successfully removed by freely removing the diseased part of the bladder, provided the peritoneum is not involved. Soft or hard carcinoma of the middle third of the bladder may be dealt with in the same way, provided the ureteric orifices are free. The small resultant bladder expands; the entire bladder except the trigone has been removed (Nicolich of Trieste) and a new bladder, capable and capacious, has arisen in its place after the suprapubic wound closed.

Carcinoma of the trigone and involving one or both sides demands first bilateral renal drainage (bilateral nephrostomy or bilateral ureterostomy), and then the entire removal of the bladder vesicles and prostate, or bladder and vagina. The success of this serious mutilation depends on early interference and absence of infiltration toward the rectum.

Hemicystectomy has not proved of any real value.

Stone in the Bladder.—This familiar and once dreaded disease is now no longer frequent nor feared in civilized countries.

The modern water supply and improved dietetics have reduced its frequency; modern surgery has not only removed much of the misery

inseparable from its neglect, but incidentally has curtailed its actual production by removing routinely and early one of the important agents in its formation, the enlarged prostate.

The varieties of "stone" met with are the uratic, oxalic and phosphatic groups. The former (uratic and oxalic) are usually primary formations; as often as not they are immigrants from the kidney as sand or small concretions which increase in size after they have reached the bladder. The phosphatic, being secondary to cystitis and therefore mainly septic, are born and grow in the bladder.

It is thus important to ascertain the earliest symptoms of departure from urinary health. Did renal pain or colic antedate the bladder symptoms, or did the bladder distress commence the symptoms of the disease?

Symptomatology.—This differs in the three ages of man, for woman is rarely affected.

In children the belly pain of descending grit or sand is often overlooked or misunderstood and, if hematuria has not been an accompaniment, the first indication is screaming during micturition and pulling at the end of the foreskin. As the same symptoms, but in a less marked degree, occur in meatal fissure with uratic urine, a careful routine examination of the urethral orifice is always necessary.

In the adult the earliest symptom of the immigrant having actually entered the bladder is pricking in the perineum. This is often preceded by that frequency of urination and penile pain which are caused by the transient lodgment of the stone in the terminal part of the ureter. With the perineal pricking there is generally a sense of obstruction to the stream, or an intermittent abrupt stoppage.

These symptoms decline as the stone enlarges or its surface becomes smoother, and pain of a characteristic character appears. This is experienced at the end of the penis on micturition or jolting. If cystitis supervenes the pains of this complication are superadded to that already noted. An attack of stone is merely an attack of cystitis localized to the immediate neighborhood of the stone; if severe or lasting, the entire viscus is involved.

As the stone increases in size, the penile pain becomes continuous. It is increased by jolting, walking, especially downhill or downstairs, or it is evoked by any sudden angular movement such as turning in bed or getting into bed or bending the body. With the very large stones the patients feel something "shift inside" on turning over at night.

The frequency of urination is a marked feature and is increased by movement.

Hemorrhage is never severe and is directly influenced by movement, ceasing during the hours of sleep.

Stone in men in the prostatic age—over 60—reveals itself merely by blood after exercise. Indeed quite a collection of smooth, round, uric-acid stones may be present in a post-trigonal or post-prostatic furrow without evoking much discomfort beyond an increasing frequency of urination upon exercise.

Once the stage of cystitis has been entered and the symptoms of this complication are superadded to those of stone, the foreign body makes its presence acutely felt by penile, perineal and even suprapubic pain. Often, however, provided the bladder has not become much infected, these symptoms abate on rest and the urine regains its clear and normal aspect, though evidence of stone can always be obtained microscopically. Those in catheter life may develop unsuspected stone of large size.

The diagnosis rests first on the clinical evidence. The diseases simulating stone can generally be easily defined.

Bacillus coli nephrotrigonitis, bacillus coli cystitis, tuberculous cystitis are all differentiated by the bacteriologist. Clinically they evoke, in contradistinction to stone, a decided night frequency. Infiltrating carcinoma of the bladder and prostatic carcinoma can be eliminated at once by rectal examination.

Cystoscopy, in expert hands, reveals the true nature of the complaint, and for the general physician the ordinary sound, passed aseptically and while the patient is in bed, with a well-filled bladder and the hips raised, is of approximate value.

The X-ray is only of use in phosphatic or oxalate of lime calculi, and is at best a poor substitute for expert cystoscopy or the sound.

The Treatment of Stone.—The scientific method of treating primary stone of all ages up to the prostatic age, but not including true prostatics, is by litholapaxy at the single sitting and the use of the cystoscope at the close of the evacuation to show a cleared bladder. In skilled hands, the death roll is 3 per cent. With those who are unskilled in lithotrity work, although operators, the suprapubic removal is the best expedient (mortality 10 to 12 per cent.). In secondary stone, where the nucleus is a foreign body or cystitis is great and the bladder contracted and friable, suprapubic lithotomy is the rule. In the true prostatic, supra-

pubic cystotomy and removal of both stone and prostate is without doubt the wisest expedient.

The Neuroses of the Bladder.—But little is known about the true innervation of the bladder and less about the diseases which arise when the nerve supply to the organ is deranged.

Certain well-marked clinical groups, however little their causation is understood, are recognized as existing and are treated empirically.

The commonest and least important is the bed wetting of children (nocturnal enuresis), a distinct automatic reflex spinal act expressive of a local stimulus which has not reached the upper centers and which is, therefore, uncontrollable. Children affected in this way sleep heavily; their bladder neck is highly sensitive, and readily reacts to light stimuli. In some cases sources of local stimuli may be found, such as phimosis, congenital narrowing of the urethra at the fossa navicularis, worms.

If such are absent and neither mental deficiency or spina bifida are present, the child is treated cautiously with muscle sedatives (belladonna) or vasodilators (thyroid), or the prostatic area, or the urethra behind the compressor muscle in the female, is excited by electrolysis. Intradural injection of normal serum, dry cupping of the lumbar spine, nightly, have their advocates.

If the weakness continues after maturity, operative measures must be employed.

Stammering of the Bladder (Paget).—This is an old-fashioned term, euphemistic but convenient, which is used to designate a group of neuroses, the main feature of which is a lack of co-ordination between the detrusor and sphincter muscles whereby retention of urine ensues.

In slighter cases this may be quite a transient inhibition, the sufferer being able to pass urine when alone or unobserved, but in the severer forms the struggle to get rid of the urine may last two or more hours and be repeated daily until finally catheterization is resorted to and the bladder becomes paretic and liable to all the various disabilities and dangers incidental to the disease—cystitis, calculus, diverticula, pyelonephritis. It is rare in women.

It is probable that sclerosis ensues in the sphincter of the bladder, aggravating the evil and depriving the patient of the chance of a complete cure by operation. Some relief can be obtained by cleanly dividing the compressor urethræ.

Atony of the Bladder (Spinal).—The two main forms encountered are those noted in men. One form occurs some years after a known

syphilitic infection. It is accompanied by an absence of knee-jerk, and probably an intramedullary lesion; the other group is characterized by an exaggeration of knee-jerk, and in this there is probably an extramedullary gummatous lesion (meningitic?). Other symptoms of spinal trouble usually coexist in both varieties and lead inferentially to the correct diagnosis.

The symptoms generally commence with a difficulty in urination, a forceless stream, which is improved by the act of straining in defecation. Consequent upon the loss of muscle power is the gradual accumulation of residual urine, then the frequency of over-distention, and finally the incontinence at night due to the same evil.

Bladder crises are extremely rare.

If there be a syphilitic history, the attempt to relieve by salvarsan is imperative. Especially is this indicated in the extramedullary group where there are probably spirochætæ which are assailable through the vessels. Iodides, however, increase the atony, but nux vomica, ergot and other muscle stimulants are valuable.

The aseptic catheter should be resorted to, and if cystitis ensues the patient should be carefully watched lest stone should insidiously form in the insensitive bladder. Litholapaxy in the *inelastic* bladder of tabes is fraught with the danger of uncontrollable hemorrhage and clot retention.

NOTES ON OPERATIONS UPON THE BLADDER

Foreword.—Urinary surgery differs from all other forms of surgery in this, that at the back of any operation is the menace of a kidney either obviously or latently impaired.

Nowhere in the tract is this potential danger greater than in the bladder where the area of destruction, of bacillary and toxin production and absorption, is comparatively greater than elsewhere. Moreover, the chronic diseases of the bladder demanding operative interference lend themselves to the production of this subtle dynamic. The bacteria and toxins of all inflammatory conditions of the kidney must escape from the body by way of the bladder and may, therefore, sensibly depreciate its stress resistance. All obstructive disease of the ureter, whether papilloma or carcinoma, vesical stone, or prostatic outgrowth, must dilate one or both ureters, and one or both renal pelves and thus disturb the circulatory and secretory balance of health.

This being so, bladder surgery aims at rigid asepticity, the freest drainage and the least possible destruction.

Suprapubic Cystotomy for Stone, Foreign Body, Tumor.—The simpler the technique is, the better. The cleansed bladder is filled with 8 oz. of mercuric chloride solution 1 in 10,000 (air has resulted in several tragic deaths), the forefinger of the gloved left hand is placed on the pubes and a plunge made with a long sharp scalpel immediately above it and an incision 1¼ in. long is made medianly upward; skin, subcutaneous tissue and the recto-pyramidalis fibers are cut through, a quarter of an inch always being left between the lowest separation of the muscle fibers and the bone so that the insertion of the muscle is never interfered with and future hernia avoided. With a little movement the finger reaches the posterior surface of the pubes and rests on the anterior wall of the bladder.

More solution is now run into the bladder which rises freely under the watchful finger, which gently makes, as the bladder distends, upward sweeps to lift away any peritoneal fold from the bladder.

Long retractors expose the anterior surface of the bladder to the rays of a strong forehead search lamp. The knife is again taken and plunged boldly backward and downward into the bladder and the gloved forefinger slips into the hole as the knife is withdrawn. With practice the bladder incision can be made to merely admit the forefinger. An elbowed retractor is inserted into the bladder and its upper angle is held up while the solution is run off through the catheter still lying in the urethra. The finger now explores the base of the growth or the size of the median prostatic lobe, or the size of the stone, or notes the position of large hernia. Four long, 1- or 2-in. broad retractors are dipped, one after the other, into the bladder and so arranged that they cover every part of the incision. A silver Fergusson speculum (a caisson), of a size commensurate with the object to be effected is taken and slipped into the bladder between the retractors which are now withdrawn. Any medium is sponged out and the speculum is directed toward the offending visitant.

No sound surgery can be effected without the strong search lamp on the forehead; with it the most delicate work can be accurately accomplished.[1] If it is a prostatic outgrowth, it can be incised wherever the line of cleavage should follow (*vide* prostate). If a vesical pedunculated growth is present the main mass of the growth can be lifted up and the relations of its implantation to the ureteric orifice noted. The base is then cut clean away with appropriate curved scissors and the

[1] Used by the author since this (the caisson) method was introduced by him to the Medical Society of London in 1892.

bleeding vessels picked up and twisted. All satellite growths (previously marked on a bladder map during the cystoscopy) are similarly treated; few need hemostatic forceps, a minute swab with strong ferric perchloride solution applied for a second is sufficient. Should the operator be doubtful of the base, he takes a hot Paquelin cautery and destroys it more effectually.

The ureteric orifice is never destroyed by a wise surgeon unless carcinoma is present.

The bladder can, area by area, be thus emptied of growth and without risk of much hemorrhage.

The bladder is then freely drained suprapubically; no stitches are used in the bladder unless the entire wall has been removed with the growth. No catgut ligatures should be used to check hemorrhage; they only form nuclei for stone.

It has lately been advocated to open the peritoneum, incise the posterior wall of the bladder and remove the growth or growths by this route. There is no difficulty in the peritoneal route. It mutilates more and does not, in some hands, increase the facility or diminish the mortality. It is unnecessary if the tumor be benign and the base freely movable on the submucous layer. Should, however, the first touch of the exploring finger reveal the growth to be malignant the question arises, can it be removed along with the entire wall of the bladder and the danger of recurrence avoided? If so, the peritoneum must be opened, and freely. Experience has shown that cancer of the upper third of the bladder, if it has not entered the lymphatics, can be safely cured by merely cutting away the upper half of the organ. With a little manipulation the adjoining under-loosened peritoneum can be closed in and the bladder drained suprapubically for a few days without danger.

If the cancerous growth affects the middle third of the bladder and the surgeon can remove it and leave a healthy trigone and undamaged ureteric orifices, it is wise to attempt it, in which case the entire upper two-thirds of the viscus has to be sacrificed. It is remarkable how firmly the preperitoneal tissues mat together in making a bladder substitute over this basal stump. There is nothing formidable in either procedure provided a strong headlight is used and the peritoneal gap is filled in either by the uterus in the female or the detached peritoneal flaps in the male.

The treatment of confirmed cancer of the base is, however, a matter of careful consideration. It rarely offers any hope of radical cure. Failing complete cystectomy, much of the agony can be relieved by perform-

ing a double ureterostomy. An abdominal incision so planned as to reach the ureter as it crosses the common iliac artery will allow of it being detached from under the peritoneum and so cut as to allow the divided proximal end to be stitched without tension into the incision. A fine catheter passed into each ureteric opening can be worn indefinitely and contraction prevented. The surgeon remembers that one ureter is always enlarged and both may be in this condition. The danger is ascending pyelonephritis and cicatricial contraction of the opening.

Total *cystectomy* in the male is a tedious operation. The operative mortality is said to be 50 per cent., but it is now always preceded by bilateral renal drainage or bilateral ureterostomy and the death rate is much lower. It would seem that the ureterostomy is the better drainage method as it is easier and less destructive. Either plan is carried out 14 days or longer before cystectomy is attempted. If the ureters are selected the operator will not act unwisely if he ligates at the same time the anterior branches of the internal iliac which run to the bladder on both sides; this reduces hemorrhage and shortens the time expended on picking up vessels.

Either the transverse or the vertical incision or a combination of both routes is employed. The bladder is not opened, indeed if it is not filled with growth, a little medium is injected in order to slightly distend it so that it is grippable. The secret of rapid cystectomy is the use of judiciously directed traction force on the bladder. The bladder, seminal vessels and prostate are then dissected cleanly out. The only bleeding (oozing) that is difficult is from the dorsal veins of the penis as they form the plexus of Santorini; undertying the dorsal vein on the penis does not assist. Lateral flaps of peritoneum are now lifted and brought together over the middle line and united. A urethral catheter serves as a drain and the abdominal wound is closed.

In the female the peritoneal gap is filled by lifting up the uterus and attaching it with its adnexa over the defect.

Removal of Stone, Foreign Bodies Suprapubically.—When the finger enters the bladder through the suprapubic incision and discovers stones which have to be removed, the operator mentally decides which sized speculum will permit of their being withdrawn through it. By this means the wound is not smeared by the septic surface of the stone, nor powdered, nor ingrained by the stinking phosphatic chips which the forceps crust off its cortex in attempting to drag it through the wound. Should the stone be evidently too big to come through a speculum, the wound areas are covered with apposed retractor flanges and the stone

extracted between them without touching the wound. The bladder is then swabbed out with mercury solution and a large drain placed in the upper part of the bladder before the wound retractors are withdrawn.

If saccules need sponging out with mercury solution, or cauterizing with a Paquelin point, either can be done through the speculum under control of the eye. If a diverticulum has a narrow orifice and a fair sized cavity, it is better removed and the procedure, though generally simple, may prove even dangerous. The difficulty and danger varies as to whether inflammation has glued it to the peritoneum or the great vessels or not. As a rule if a stone fills the cavity, it is better to leave it *in situ* in order to guide the dissection. The surgeon opens the peritoneum, incises and reflects the peritoneum covering the hernia and attempts to invert it, if small, into the bladder by pressure, pleating the peritoneum over the depression and closing the peritoneal cavity wound; the hernia is then resected from the bladder aspect and the edges stitched with catgut. Some use silk without knotting and leave both ends free outside the wound. After 14 days the end is gently pulled on and the entire suture removed.

In all hernia operations the bladder is drained more freely and longer than is usually necessary.

SECTION XIV

DISEASES OF THE PROSTATE

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THE PROSTATE

Injuries of the Prostate.—Injuries of the prostate are uncommon. They form two groups: those which are part of other injuries produced by external violence and implicating the perineum, rectum, or bladder; the second, and unfortunately a very common group, results from violent or unskillful instrumentation of the urethra.

As regards treatment of the first group, no special mention need be made, excepting that it must be borne in mind that, if the prostatic urethra is opened, extravasation of urine will follow with all its disastrous sequelæ.

The greater part of the injuries of the second class are seen when the patient has his first attack of retention. If the introduction of a soft or flexible catheter has failed, metal instruments are generally resorted to and, if used injudiciously, may perforate the urethral wall. A practitioner fails frequently to realize that the obstruction is one of blocking or distortion of the urethra and he is apt to imagine that it is a question of caliber. So, after failing to introduce ordinary instruments, he resorts to a very small sized metal catheter, a most dangerous instrument, which is readily pushed through the urethra, even when passed by skillful and careful operators. The resulting injury may vary from a superficial abrasion of the mucous membrane to a complete penetration of the urethra. The resulting reaction will naturally vary according to the anatomical lesion. The milder injuries may produce only a superficial bleeding, with a varying degree of constitutional reaction. If considerable bleeding results and clots are formed, these may become a secondary cause of obstruction. If it is suspected that some such injury has resulted, it would be wiser, for the time being, to desist from further

urethral instrumentation and relieve retention by repeated suprapubic aspiration or drainage. A careful watch should be instituted for signs of urinary infiltration, and its consequences minimized by a prompt external urethrotomy, with drainage of bladder by a perineal tube.

Inflammation of the Prostate.—Inflammations of the prostate may be either acute or chronic. They may be part of a general systemic infection, metastatic, an extension from a contiguous focus of inflammation, or the result of trauma. In some cases the etiology is by no means clear and an abscess may develop apparently spontaneously, although this class of cases is the least common. Anatomically, we may have a mild grade of inflammation involving all the tissues of the gland. This condition may be only temporary and may either (*a*) undergo resolution, or (*b*) form an abscess.

Fig. 152.—Multiple abscesses in an enlarged prostate, catheter infection.

In the abscess form, we have frequently the formation of several small foci which later tend to coalesce and form one large abscess; or we may have a single abscess limited to one lobe or one portion of the gland. Acute inflammation, in the vast majority of cases, is a sequel of gonorrhœal infection, usually in the later period, from two to four weeks after the onset of the disease. The smaller proportion is the result of trauma, due to unskillful or careless catheterization (Fig. 152).

The course of an acute abscess is progressive. At first, it tends to remain localized within the gland. Finally, it breaks through the capsule and tends to reach the surface in one of several ways:

1. It may break into the urethra, resulting either in complete or temporary relief of symptoms, or causing urinary infiltration of a subacute or chronic type.

2. It may break directly into the rectum, resulting in a recto-

prostatic fistula or a recto-urethral fistula, if the abscess has also broken into the urethra.

A certain number of these abscesses tend to burrow laterally alongside of the rectum and to discharge at the side of the anus. In this situation, unless the antecedent facts are known, they somewhat simulate the ordinary fistula *in ano*.

Lack of recognition of the cause of this particular form of sinus necessarily results in improper methods of treatment, and it must be borne in mind, that a large number of failures after operations for fistula *in ano* in men are due to the overlooking of the prostate as a source of suppuration.

Symptoms of Acute Prostatic Inflammation.—The history of the antecedent infection or trauma should be available and, in the case of acute specific infection, its possible occurrence should be anticipated.

The symptoms usually appear after the subsidence of the acute gonorrhœal urethritis, when the discharge is less in quantity and consistency. Pain is generally the earliest symptom, first on passing water; later there is increased frequency of urination and finally tenesmus. Pain sooner or later is felt in the perineum or rectum and is increased by defecation. Pus is noted in the urine in variable quantities. In acute cases, constitutional manifestations of an acute infection appear, sometimes of a great severity, the patient being extremely ill. Rectal examination will show in the earlier stages only increased tension of the prostate, diffuse tenderness to the touch, greater on one side if the lesion is localized. Definite fluctuation is not appreciable until a good-sized abscess is present; one should be able to recognize the condition before it is so extensive as to give this manifestation. Pressure on the prostate will usually cause the evacuation of some pus per urethram.

Chronic Inflammation of the Prostate.—A number of infections or agencies may operate so slowly and so insidiously that an abscess may develop with few or no obvious symptoms until it has attained considerable size, or gives rise to constitutional manifestations of a chronic sepsis whose etiology is not apparent.

For the sake of completeness, one may also mention tuberculosis of the prostate. A very few cases have been reported of primary tuberculosis of the prostate, but for all practical purposes, we must consider it as an extension and part of tuberculosis in the remainder of the urinary tract, constituting a grave and extensive condition and calling only exceptionally for direct surgical treatment, *e.g.*, in case of the formation of a large abscess.

Treatment of Inflammation of the Prostate.—For the ordinary acute prostatitis developing in the course of a specific infection, no direct surgical treatment is indicated unless the condition passes to the stage of abscess formation.

Treatment of Acute Abscesses.—Prophylaxis. Avoid gonorrhœa. Eliminate gonorrhœa and 95 per cent. of prostatic abscesses will be wiped out.

Early stages. Rest in bed. Discontinuation of all direct treatment of an existing gonorrhœa.

Second Stage. The patient feels acutely ill. Spontaneous pain and pain on defecation; constitutional manifestations of infection. To rectal touch, prostate is swollen diffusely and is painful; fluctuation may or may not (probably not) be detected. This is the "golden moment" to operate before the abscess has burst with unpleasant or uncontrollable sequelæ.

It is unquestionable that a certain proportion of these acute abscesses find a spontaneous cure by the discharge of pus into the urethra; yet it must be emphasized that this method of cure, though gratifying, is exceptional.

Generally, as soon as the formation of a definite abscess is diagnosticated, it is wise to anticipate the various unpleasant results that may occur, by giving prompt surgical relief. The form of operative treatment will depend to some extent on whether the abscess has perforated the capsule, or whether it is still retained within its limits; also whether the abscess involves, as it generally does, most of the prostate, or (very exceptionally) is sharply limited to one lobe.

Operative Treatment of Acute Prostatic Abscess.—The patient is anæsthetized. An external urethrotomy (with the aid of a staff) is made. The finger is passed through the urethrotomy opening into the prostatic urethra, when palpation will either reveal the communication of a suppurative process with the prostatic urethra, or the finger can be made to penetrate directly into the abscess mass on one or (usually) both sides of the urethra. The bladder should then be drained by passing a perineal tube into it and the suppurating foci in the prostate should be well drained by packing them with strips of gauze, the ends of which are brought out alongside of the tube.

The after-care of these cases being necessarily tedious and it being desirable to provide very free drainage, the preliminary external incision should be made sufficiently large to allow for efficient after-treatment.

In exceptional cases when the abscess seems sharply limited to one

lobe, exposure of the prostate may be secured thorough a perineal dissection. The prostatic urethra is identified by filling it with a sound. The abscess then may be directly incised and drained without opening the urethra. This form of operation, however, has very limited indications. When an abscess has burrowed and come to discharge externally, laying open the sinus widely till the source of suppuration in the prostate is exposed and drained may suffice without opening of the urethra.

The abscesses communicating with the rectum sometimes leave unpleasant fistulæ which may require, eventually, a very extensive operation for their relief. Occasionally, the prostate may be so damaged or the process may be so disseminated, that it may seem difficult to treat it effectively without the removal of the prostate *in toto*. That procedure has been recommended and practised by Alexander. It has never been generally accepted. It probably is seldom called for and should not be used except in unusual conditions as the after-results are not good.

Chronic prostatitis usually calls for no special surgical treatment.

Tumors of the Prostate.—For all practical purposes, all tumors of the prostate may be considered malignant.

Carcinoma of the prostate is generally in the form of an adenocarcinoma. It is of slow growth and remains confined within the limits of the gland for a long time. While so limited to the gland itself, it does not attain great size. When it gets beyond the boundaries of the gland, it may present in the bladder, posteriorly toward the rectum, or as demonstrated by Young, upward along the base of the bladder toward the vesicles. Metastases are very slow in forming. Two favorite sites for metastasis are the retroperitoneal glands and the bones.

Carcinoma of the prostate is a disease of middle and elderly life, but there are exceptions. The author observed it in a man of 29. Younger cases, also, have been reported but it is possible that some of these have been confused with the sarcomata.

Symptoms of Carcinoma of the Prostate.—Direct symptoms may be delayed until the prostate assumes considerable bulk, or produces urinary obstruction, or results in vesical hematuria. Pain is not a prominent feature unless attended with obstruction. In a smaller class of cases, where the growth extends posteriorly and assumes large size, a certain amount of rectal obstruction may be produced. The most constant of the initial symptoms, for which patients come under observation, is that of urinary obstruction and, in the earlier cases, there

may be little or nothing to distinguish them from the ordinary hypertrophy of the prostate. In fact, many such have been removed, their nature undiscovered until revealed by a routine microscopic examination.

When the tumor has attained considerable size, its presence is usually easily made out by a rectal examination. On palpation, one generally gets a sensation of greater hardness and more irregularity than in the hypertrophied prostate. The cystoscopic examination, if feasible, may reveal or give a hint to the nature of the condition, if the tumor protrudes intravesically. At first, the patient may show few or no constitutional manifestations, but through the occurrence of hemorrhage and cystitis, the general health deteriorates rapidly, and so noticeably, that this feature leads to differentiation from the troubles resulting from ordinary hypertrophy.

Course and Prognosis.—The course is very chronic for the average variety, perhaps three or four years or even more. A rapidly growing form of carcinoma attaining large size, particularly in a younger individual, may result fatally in a few months.

The prognosis is bad. Theoretically, we should hope to cure some of these patients when the process is so limited as not to be revealed excepting by microscopic examination. Yet experience has shown that metastases may be dormant and not develop for some years after the removal of the original tumor.

Treatment may be radical, or palliative. We may attempt to remove the carcinomatous prostate at an early stage by the operation of total prostatectomy, hoping that even if we are not successful in attaining a permanent cure, the relief of urinary obstruction and other distressing symptoms may be secured for years. Before undertaking a radical operation, we should have a pretty clear idea that such an operation is feasible, for imperfect procedures leave the patient in a very distressing condition. The very radical operation, such as proposed by Young, which removes not only the prostate but also the neck of the bladder and the seminal vesicles, is hardly a justifiable procedure.

Palliative.—Where obstruction to the outflow of urine exists and catheterization cannot be accomplished or causes too much pain, much relief can be obtained by a permanent suprapubic drainage which should be done after the method which gives most complete control of the vesical fistula.

Sarcoma of the Prostate.—Sarcoma of the prostate is a rare condition. As this condition is for all practical purposes inoperable, the

opportunities for obtaining material for an accurate microscopic diagnosis are necessarily limited. In 1910, the author could find records of only 36 authentic cases. A number of these have been seen in young individuals or children.

FIG. 153.—Dragammatic representation of diminution of urethral caliber by lateral compression of the hypertrophied lobe.

Microscopically, these tumors are made up of any of the cells found in the different sarcomata. The small round cell variety appears to be the commonest and is, as usual, the most rapidly growing, the most rapidly fatal. The symptoms are those of a rapidly growing tumor, producing early obstruction either urinary or rectal. Rectal examination will show that the prostate is unusually large for a young individual.

It may or may not show irregularity. Hemorrhages and secondary vesical infection give acute and severe symptoms. The course is, for the most part, acute and death is a question of a few months. Treatment is purely palliative. Radical cure cannot be expected. Suprapubic drainage to relieve urinary obstruction may be indicated.

FIG. 154.—Diagram of the lateral deflection of the urethra by excessive hypertrophy of one lobe.

Hypertrophy of the Prostate.—Hypertrophy of the prostate takes place so frequently in late middle life or in elderly men as to be almost normal. Anatomically, the change consists in the hypertrophy of one or more of the tissues forming the structure of the prostate. For the

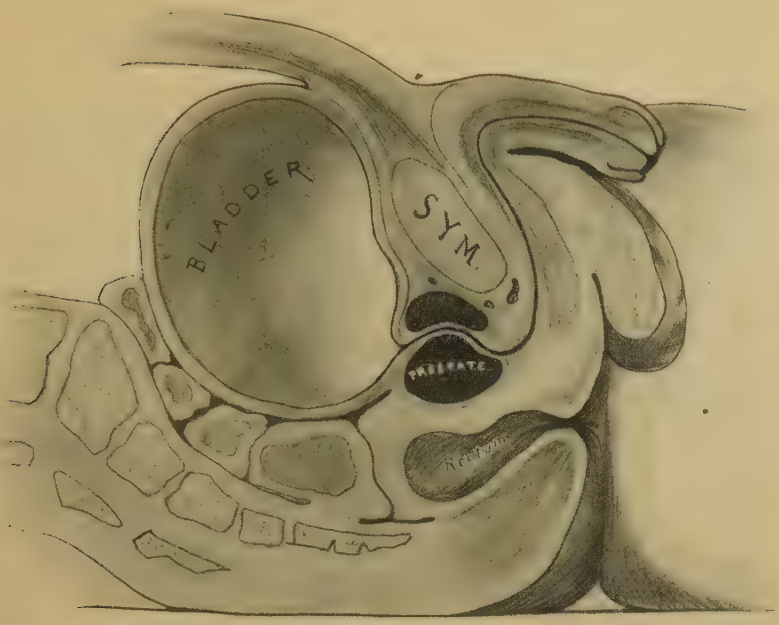

FIG. 155.—Crowding upward of the prostatic urethra, changing both axis and caliber.

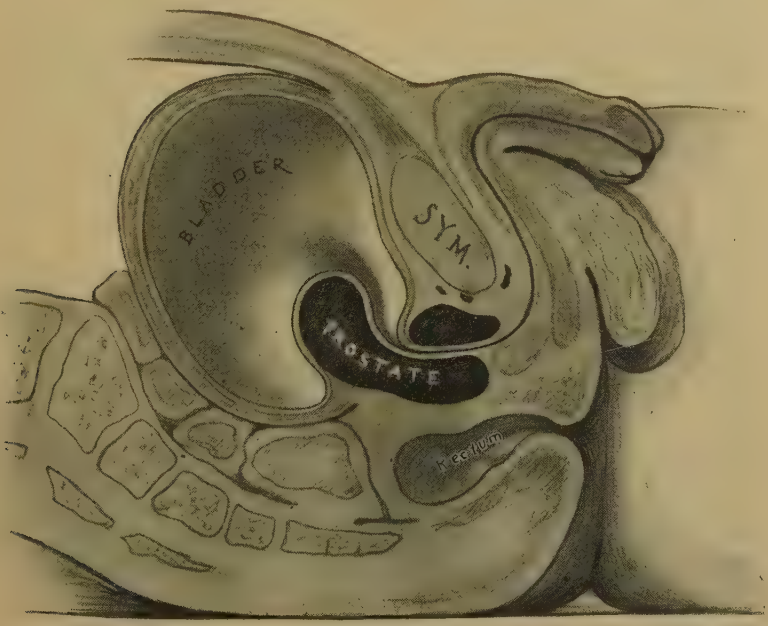

FIG. 156.—Diagrammatic illustration of intra-vesical projection of hypertrophied prostate.

most part, this change takes the form of glandular hypertrophies forming a large number of adenomata. There may be more or less hyper-

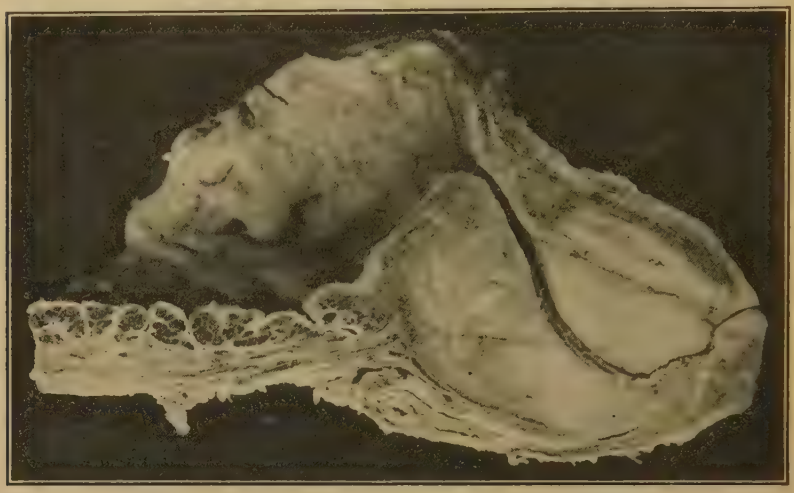

FIG. 157.—Marked deflection of the urethral axis. (From collection of the late Dr. Sam. Alexander. Lent by E. L. Keyes, Jr.)

FIG. 158.—Intravesical Projection. (From collection of the late Dr. Sam. Alexander. Lent by E. L. Keyes, Jr.)

trophy of the connective tissue and, in some cases, the hypertrophy is limited to the latter tissue, perhaps increasing little, if at all, the total

bulk of the prostate. For the most part, the bulk attained by the hypertrophied prostate is not very great. A prostate weighing 2 oz. may be described as large; 4 oz. very large; larger, enormous.

The importance of these outgrowths of prostatic tissue lies not so much in the bulk attained, but in whether or not they impinge mechanically on the prostatic urethra or the vesical outlet. That is, the prostate may be very large and yet cause absolutely no symptoms, as at no point is urinary drainage interfered with; while on the other hand, a prostate, not exceeding the normal in size, may, by a very minute change which directly impinges on the urinary outlet, cause maximum

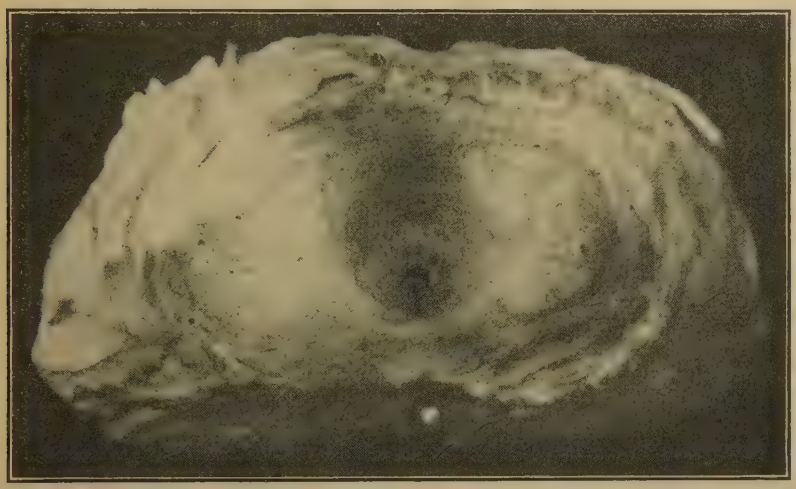

FIG. 159.—Third lobe—transverse section. (Collection of the late Dr. Sam. Alexander. Lent by E. L. Keyes, Jr.)

disturbances. The obstruction produced by a hypertrophy of the prostate may be operative in the prostatic urethra, which becomes compressed by the tissue adjoining it impinging on its lumen (Figs. 153, 154 and 155), or the obstruction may take place within the bladder by an intravesical projection of prostatic growth (Fig. 156).

A marked example of elongation and upward deflection of the urethra is seen in Fig. 157.

The So-called Third Lobe.—This third lobe (Fig. 156 and Figs. 158 and 159) may assume bizarre shapes, may be pedunculated, allowing it to fall into the vesical outlet acting as a ball valve, or it may from a shelf (Fig. 160) obscuring the vesical outlet, or completely surrounding it in the form of a "collar-like" obstruction (Fig. 161). It must be remembered that, mechanically, several forms of this obstruction may be

operative at the same time. That is, removal of a projecting third lobe may not relieve the obstruction due to compression of the prostatic urethra, where an enlarged lateral lobe coexists (Figs. 162 and 163).

Symptoms of Prostatic Hypertrophy.—The symptoms must be divided into the primary symptoms, those of obstruction alone; the secondary or later symptoms of cystitis; and the final or terminal symptoms, those of "surgical kidney."

The early symptoms are insidious and may exist a long time without causing the patient much discomfort and therefore often escape his critical observation. Some time between 50 and 60, later rather than

FIG. 160.—Large shelf-like third lobe. (From collection of the late Dr. Sam. Alexander. Lent by E. L. Keyes, Jr.)

earlier, the patient will begin to get up at night to pass urine; at first only once and later, with aggravation of symptoms and developing irritation as a result of cystitis, quite frequently. Sooner or later he finds that, in addition to getting up, he has to make greater expulsive efforts. These expulsive efforts may also be manifested in the development of inguinal hernia and hemorrhoids.

The second stage which represents the development of cystitis is precipitated either by the use of the catheter or by other instrumentation or represents the constant stagnation of a certain amount of urine, so-called "residual urine." The bladder is unable to expel this and the

patient fails to empty the viscus completely. The urine shows signs of an ammoniacal cystitis, and the presence of mucus and pus. This cystitis increases the prostatic irritability and the patient will have increased frequency of urination day and night, attempting to pass his water every hour or less. In this stage the symptoms may be aggravated by the formation of a calculus or the accumulation of phosphatic deposits.

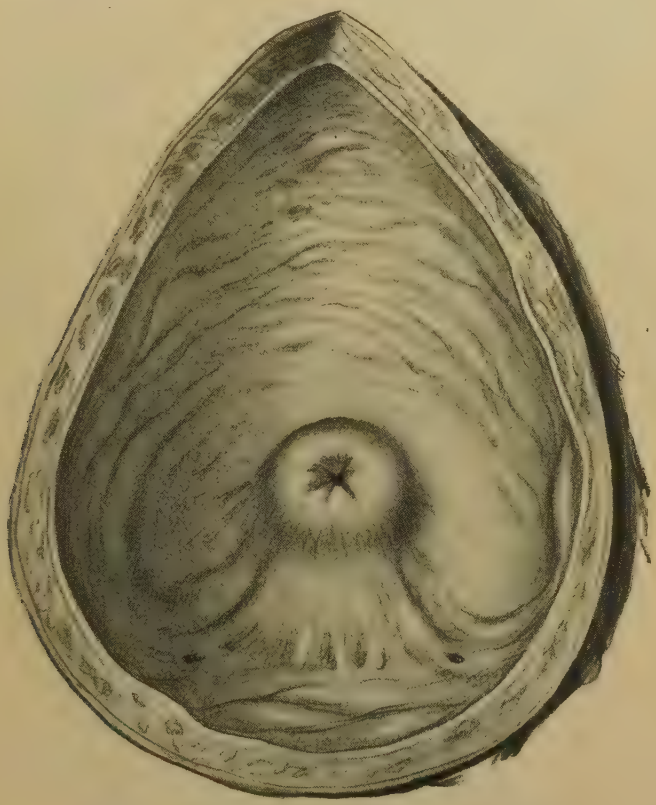

FIG. 161.—Collar-like obstruction of vesical neck.

In the terminal stage the patient shows signs of a severe and long-standing chronic, diffuse nephritis, polyuria, low specific gravity, and marked diminution of urea output. Most cases will show increased arterial tension and a low grade of uremia with occasional exacerbations, death finally being brought about by complete suppression of the renal function.

Diagnosis of Enlargement of the Prostate.—The diagnosis of enlargement of the prostate by physical examination comprises first, rectal

FIG. 162.—Multiple intravesical projections. (From collection of the late Dr. Sam. Alexander. Lent by E. L. Keyes, Jr.)

FIG. 163.—Hypertrophy of all three lobes.

examination. This investigation will usually show that that portion of the prostate accessible to the rectal touch is enlarged. Usually, two lateral lobes stand out very distinctly as smooth, more or less globular enlargements. It must be remembered, however, that a prostate which is obviously large by rectal examination may not in its enlargement actually impinge on the vesical outlet or interfere with urinary drainage; conversely, that a prostate which is normal or even slightly reduced in size may, by its unequal development, cause a maximum of urinary obstruction.

Examination by an urethral instrument will show a varying degree of obstruction. A steel instrument may be arrested in the prostatic urethra while a flexible instrument may slip in easily, indicating that there is a tortuous obstruction blocking the stiff instrument but allowing the soft instrument to wind its way around; conversely, in the diffuse but usually uniform collar-like obstruction at the vesical neck, a soft instrument cannot force its way through while a stiff instrument will easily make a passage for itself.

The Recognition and Determination of Residual Urine.—This is one of the most important procedures in the examination and consideration of prostatic conditions and guides us largely in the indications for treatment and the kind of treatment. It gives us, of course, a direct clue as to how much the secondary hypertrophy of the bladder muscle is able to overcome obstruction when there is little residual urine and to what extent it has failed when there is much. The patient evacuates his bladder spontaneously as completely as he can. The catheter (preferably soft) evacuates what urine has not been passed. The amount may vary from a few drops to one or more pints, in a case of average severity averaging from about 2 to 8 oz.

The Cystoscope.—Examination by cystoscope is more a refinement than a necessity in determining prostatic obstruction. In addition to locating in some cases more accurately the position, shape and size of the prostatic obstruction, it may reveal the presence of otherwise undetected calculi or eliminate the possibility of new growths.

Radiography.—Radiography has recently been used to determine the presence of a bulky prostate in a very ingenious manner. Dr. Hyman in his paper on "The Roentgenographic Diagnosis of Prostatic Enlargement by means of Air Inflation of the Bladder," says: "The method is based on the well known fact that a medium of air or other gaseous substances intensifies the Roentgen rays, rendering objects clearly visible which, in other medium, may be indistinguishable

(Fig. 164). The technique is simple; a small-sized rubber catheter is introduced into the bladder, the organ emptied, and the inflation apparatus attached. This consists of an ordinary rubber hand-bulb, to which is attached a glass bulb filled with cotton in order to filter the air. The air pressure can be fairly well gauged by this apparatus. The bladder is very slowly and gently inflated until the patient com-

FIG. 164.—Enlarged prostate shown by radiography of bladder filled with air.

plains of a sense of fullness. It is not advisable to inflate any further, for a violent and painful spasm may be produced, expelling both the air and the catheter. The catheter is then withdrawn and the escape of air from the urethra prevented. The plate and X-ray tube should be adjusted before inflation so that the exposure can be made immediately. The patient is placed in the ventrodorsal position."

Hemorrhage.—Hemorrhage as a result of prostatic obstruction is an exception, not the rule. It is rarely seen excepting during a state of marked engorgement from the attempts to overcome acute retention, the patient suffering from a severe tenesmus and trying or succeeding in frequently passing a few drops of urine. Bleeding is most frequently seen as a complication of prolonged or injudicious instrumentation. When none of the above conditions is present, hemorrhage is more likely to mean the complicating presence of a stone or obstruction due to malignant disease of the prostate or bladder.

Course.—The course of prostatic hypertrophy is chronic, never receding. It is subject to acute exacerbations. Many patients have mild degrees of obstruction that give them comparatively little trouble and do not increase in the course of time, so that they may go on indefinitely with little change. This condition, however, is the exception, not the rule. The obstruction increases and secondary manifestations of cystitis appear. With a well marked cystitis the progress is most rapid and patients will die, on the average, in about five years of "surgical kidney," although it must be acknowledged that there are marked exceptions and that some of these patients manage to drag out many weary years in prolonged suffering.

Prognosis.—In general, the prognosis is fair. While many patients have prostatic obstruction, it is only a minority who have marked obstruction and the severest symptoms just described.

Treatment.—Prophylaxis is unknown. The author believes, however, that in a certain number of patients the anatomical conditions allow of checking of the progress of the disease. The collar-like form of obstruction it is believed, if treated early, can be kept open by a judicious and systematic dilatation with sounds in a fair number of cases.

When should Treatment be Instituted?—So long as the patient does not have much discomfort, does not have to get up frequently at night, does not have to make marked expulsive efforts, and the bladder empties itself completely, no treatment is ordinarily required. It is not always possible to foresee when these milder symptoms may be replaced by severer ones and of course it is judicious, if we contemplate the possibility of operative interference, to afford the patient this relief at a time when his general physical condition and his age will permit of a more favorable operative prognosis and particularly before the secondary infections have taken place or become permanent.

We have two main lines of treatment, the palliative and the radical.

By palliative, we generally understand the use of a catheter either to relieve acute and temporary conditions or systematically employed to do away with the residual urine even if the patient pass the bulk of the urine spontaneously, or as the sole means of evacuating the bladder when no urine can be spontaneously passed. The catheter is particularly called for in that condition described as "overflow." This phase represents an exacerbation of a chronic condition, the bladder becomes markedly distended, may hold several pints and, finally, the expulsive power of its walls presses out a few drops of urine and repeats this process at short intervals. This is a condition which deceives an inexperienced practitioner very frequently as he says in his own mind that the patient cannot have urinary obstruction as he is constantly passing his water. Physical examination will show a bladder readily recognizable above the pubes and the passage of a catheter will evacuate enormous quantities of urine.

The Use of the Catheter in Prostatic Obstruction.—The catheter has a dual personality. It is one of the most merciful agents in existence for the relief of acute obstruction. Used continuously in chronic conditions it kills, slowly but surely, by producing chronic cystitis with its sequel, the "surgical kidney." The fact that occasionally an individual manages to live a long time notwithstanding that the sweatband of his hat is used for a resting place for the catheter and "spit" for a lubricant does not invalidate the assertion that the catheter is but a step to the grave.

Catheterization may be required to relieve:

1. Acute retention. When the temporary contributing engorgement of the prostate or urethra subsides, it may be discontinued.

2. Chronic retention, when no urine is ever passed spontaneously.

3. Residual urine, when the patient can still pass some or most of the urine, but does not completely empty the bladder.

The kind of catheter required will vary according to the anatomical conditions. In general terms the least irritating should be used and particularly when first investigating the patient's condition. First to be tried are soft rubber catheters of the best and most reliable make; next, semi-flexible, the best being a certain French catheter of white rubber; it is expensive but easily sterilized and durable. These catheters may have olive tips or angulated extremities, "coudé" or double "coudé" (Fig. 165). Metal catheters are to be avoided and to be used with the utmost caution, as stiff instruments, particularly the small sizes, cause the most frequent damage to the prostate. Some forms of

prostatic obstruction may be more easily overcome by using a nearly straight instrument. The Trendelenburg catheter (Fig. 166), which is heavy, has only a slight terminal curve and a knob-like extremity, is very useful. Conversely, the extreme curve (Fig. 165) may be required. If absolutely necessary to use a small metal instrument the use of a suitable tunnel catheter threaded over a long (18 in.) filiform bougie will most surely guarantee against disaster.

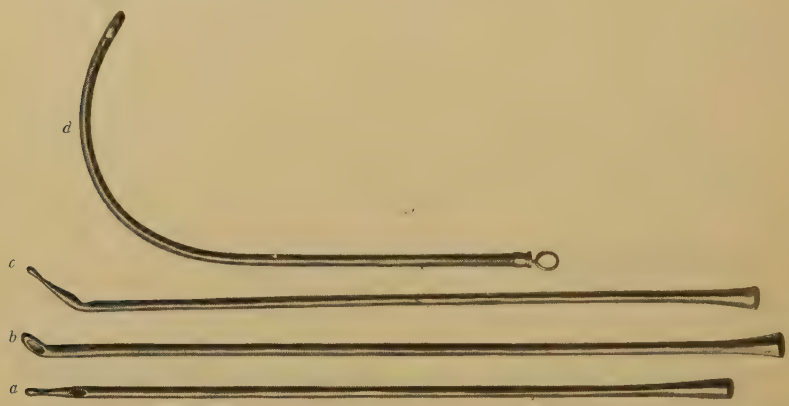

FIG. 165.—Types of catheter useful in various forms of prostatic obstruction. *a*, Olive-tip catheter; *b*, coudé catheter; *c*, double coudé catheter; *d*, extremely curved catheter.

A certain number of cases of *acute* retention return to normal conditions after the bladder has been completely and regularly evacuated for a few days. Many will, after the subsidence of acute symptoms, resume the evacuation of the bladder spontaneously but only in part; that is, a certain amount of residual urine still persists. The residual urine if in appreciable amount, say 4 oz. or more, should be treated by passing the catheter from two to four times a day at regular intervals.

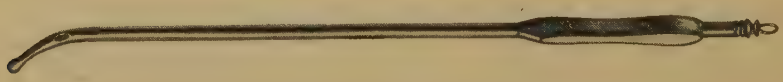

FIG. 166.—Trendelenburg's prostate catheter sound.

This treatment may also be supplemented to advantage by washing out the bladder with a bland non-irritating solution. The gradual instillation of nitrate of silver solution, ½ per cent., or the leaving in of 2 to 4 oz. of 5 to 10 per cent. solution of argyrol is to be recommended. We see cases of *acute* retention where instrumentation by any procedure is impossible or causes so much pain and reaction that it is inadvisable to resort to it frequently. In this condition aspiration of the distended

bladder over the pubes may relieve pressure and engorgement and allow the subsequent passage of a catheter or even the return of spontaneous urination. For cases with very urgent symptoms and especially if the bladder contains clots it may be wise to resort to a temporary suprapubic cystostomy for drainage. Occasionally, this procedure will suffice alone and patients will be able eventually to resume urination normally. It is, however, much more probable that such a suprapubic opening once made will become permanent as it will be easier for the urine to flow out of the sinus than to overcome prostatic obstruction. With present day technique and more favorable operative results it will be probably wiser to consider the temporary drainage as the first step of the so-called two-stage operation for removal of the prostate.

In general terms palliative treatment will be called for in those cases not attended with severe complications, where the catheter is well borne, or does not have to be used very frequently. It is more particularly called for in the milder cases whose general health, impaired kidneys, and advanced age make the risk of operation considerable. Operative treatment is called for particularly in those relatively younger individuals whose initial symptoms are severe and progressive and whom general conditions make them "good surgical risks," and it is particularly called for in individuals in whom catherization is difficult, painful, and attended with constitutional reaction and progressive sepsis. The formation of stones and calculous deposits almost necessarily calls for operation.

Operative Treatment.—Operative treatment consists in a great majority of cases in the removal of the entire prostate. It is conceivable that in a very limited number of cases a minute obstruction, sharply defined, *e.g.*, a polypoid growth presenting in the urethra, might be enucleated by intraurethral or intravesical procedures, utilizing special instruments such as devised by Young. The various operations at one time recommended and occasionally practised by a few today, such as cauterization of the prostate, have so little usefulness, if any, as to render it inadvisable to discuss them here. "Fulguration" such as described recently by Bugbee is still *sub judice* and cannot now be recommended as a normal procedure.

Methods of Removing Prostate.—There are two main methods of approaching the prostate, the suprapubic and the perineal. A few years ago there was a justifiable divergence of opinion as to the choice of operation and at times the partisans of the perineal operation seemed to be in the majority but today the overwhelming majority of operators

has returned to the total enucleation of the prostate through a suprapubic cystotomy. Some forms of perineal enucleation will probably enjoy a certain amount of popularity so long as the authors of these methods, such as Proust and Young, retain their activity. Generally speaking, in the hands of experts the perineal operation shows less shock and a slightly lesser mortality. The suprapubic prostatectomy, however, gives much better ultimate results and has fewer disagreeable sequelæ. Therefore, the operative treatment here recommended will be that of suprapubic prostatectomy; a description of Young's method is also given.

Suprapubic Prostatectomy in One Stage versus a Two-stage Operation.—Of late a number of operators have recommended that enucleation should be performed as a second stage, the bladder having been drained by a preliminary operation some days or weeks previously. While believing that such a procedure is eminently desirable and sometimes the only one that should be performed, the author doubts if it is necessary as a routine procedure. Generally speaking, the necessity of two operative procedures is distasteful to patients and often has a bad psychic effect. The procedure is more particularly called for when we first see the patient, in a stage of acute obstruction where instrumentation is difficult or impossible and there are marked constitutional disturbances. Temporary drainage of the bladder under those conditions for a week or 10 days or until the patient's general condition improves is undoubtedly a wise procedure. The first stage can often be performed under local anæsthesia, always feasible in thin patients with obviously distended bladders; in other patients anæsthesia by gas oxygen administered by an *expert* will usually answer admirably.

Suprapubic Prostatectomy.—The following is the technique used and recommended by the author and represents the evolution of different methods proposed at various periods of the development of the operation:

Anæsthetic.—General anæsthesia is necessary. With a development of a rapid technique the anæsthetic recommended above all is gas-oxygen administered by a person well skilled in its use. It can be administered safely to almost any patient. It is particularly well adapted to those operations that can be done easily in 10 minutes or less. The administration of a quarter, or even better, a third of a grain of morphine half an hour or an hour before beginning the anæsthesia will materially increase the efficiency of gas oxygen anæsthesia.

Position.—The position of the patient is of all importance. The

patient should be flat on the table, that is, the Trendelenburg position should *not* be used. The author found, on one occasion, when performing suprapubic drainage in a patient's bed, that the prostate was so easily accessible that he could not resist the temptation to shell it out, although originally no such procedure had been contemplated. It seemed to him then, and to the bystanders, that this unpremeditated operation was so much easier than any he had performed in a large experience, that there must be some special underlying condition govern-

Fig. 167.

ing this case. It was finally decided that the low position of the patient in his bed allowed the operator, so to speak, to lean down on the patient's abdomen with the operating hand, which was thereby given a greater freedom of motion and an easier application of strength to the fingers. So, at subsequent operations, these conditions (low position) were deliberately repeated and it was found that the great ease, once thought accidental, was in reality the rule. The low position is particularly important in operating with gas oxygen anæsthesia, the patient being

usually imperfectly relaxed. The low position permits the operator to bring the weight of his own body to bear on the patient's abdominal wall, thereby easily depressing it so as to allow a free and comfortable manipulation with his fingers within the bladder (Fig. 167).

Incision.—The superficial incision varies according to the amount of fat in the abdominal wall, the average being 3½ to 4 in. long. It is made in the midline between the recti muscles which are stretched apart by retractors. The bladder is easily recognized, if moderately

FIG. 168.—Finger pushed into the internal meatus. (*Squier, Surg., Gyn. & Obst.*)

full. There is no occasion for its over-distention. There is usually no necessity of pushing the peritoneum upward or of injuring the prevesical fat by dislodging it from the bladder surface. Whatever means are employed to recognize or distend the bladder, insufflation of air should *never* be used as it has undoubtedly caused a number of fatalities from embolism.

The incision in the bladder should be located as far away from the pubes as feasible, without injuring the peritoneal reflection. On either side of the proposed incision (vertical), chromic gut sutures of fair size (No. 2) should be passed double. These serve as retractors in opening the bladder and are left *in situ*, being utilized, eventually, for the closure

FIG. 169.—Finger pressing one lateral lobe anteriorly. (*Squier, Surg., Gyn. & Obst.*

FIG. 170.—Finger freeing the median lobe. (*Squier, Surg., Gyn. & Obst.*)

of the bladder. The bladder wound should originally be about 1½ in. long, admitting thus, rather snugly, two fingers. It is found that this wound dilates readily and it is rarely necessary to make a larger incision. The finger makes a rapid examination of the bladder. Stones, if any are present, are discovered and removed. The prostate is then enucleated as a whole, or piecemeal, as will be necessary in a number of cases. Enucleation is begun usually at the superior aspect of the vesical neck (Figs. 168 to 172). The finger is entered into the urethral orifice, the finger nail penetrates directly through the thin layer of prostatic

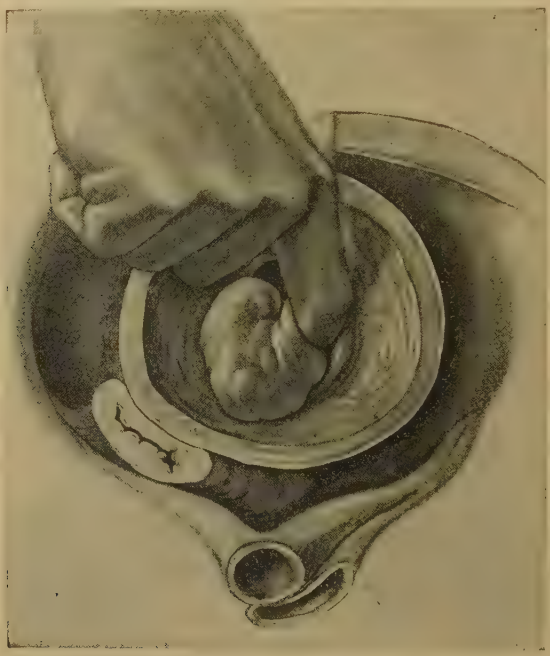

FIG. 171.—One lateral and the median lobe have been freed. Finger enucleating the other lateral lobe. (*Squier, Surg., Gyn. & Obst.*)

tissue and is pushed till it reaches the outer limit, that is, the prostatic capsule. The prostate is enucleated by sweeping the finger round it until it has been removed. In working this way, the index-finger should be kept in a hooked position so that the terminal phalanx is working away from the rectum. It is quite unnecessary to introduce the finger of the operator or the assistant into the rectum if this manœuvre of constantly lifting the prostate away from the rectal aspect is employed.

The bleeding is not frequently alarming. The blood is best evacu-

ated by using a sucking apparatus,[1] such as is now part of the equipment of most operating rooms. It should be employed to remove blood fairly continuously until the operation is completed and the patient leaves the operating room. Drainage should be employed by using a rubber or a Kenyon tube (Fig. 173) with a caliber of not less than an inch. This tube of itself will almost block the vesical incision. The original traction sutures are now tied to each other across the incision,

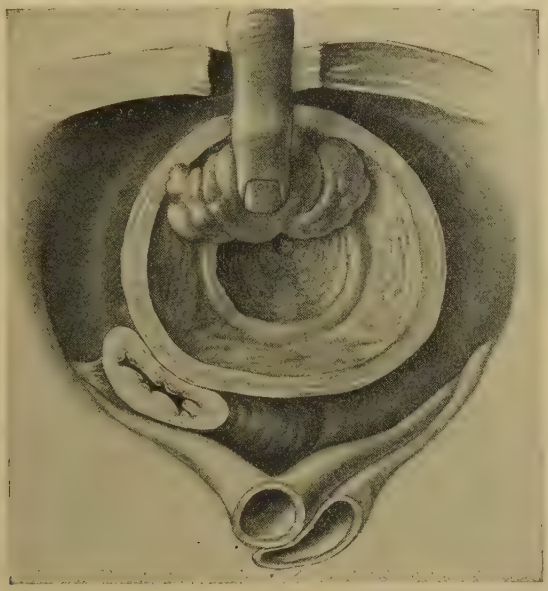

FIG. 172.—Prostate tipped up in bladder, and urethra severed close to the median lobe, posterior to the colliculus. (*Squier, Surg., Gyn. & Obst.*)

and this alone is usually sufficient to secure proper grasp of the vesical wall on the tube. These same sutures may also be passed through the muscle and aponeurosis, lashing the fundus of the bladder to the overlying tissues. The abdominal incision is best closed by passing two or three silkworm-gut sutures through all the layers. A suitable small drain may be placed in the lower angle to drain the space of Retzius. While the abdominal wall is being sutured, the sucker has been introduced into the bladder through the short, wide drainage tube. It is not discontinued till the patient is actually removed from the operating table.

The patient is now transferred, with all possible dispatch, to his bed,

[1] Kenyon, "Continuous Suction and Its Application in Post-operative Treatment." Surgery, Gynec. and Obstet., July, 1913.

where, a similar apparatus should be coupled up, in readiness to be introduced into the drainage tube so soon as the patient returns to bed. If this procedure has been properly carried out, the after-care will present a minimum of trouble. The bladder is kept at all times free from blood and therefore from the annoyance that comes from the formation of clots. In 48 hours or less, any notable oozing will have ceased, the large tube will have outlived its usefulness and may be removed, suction

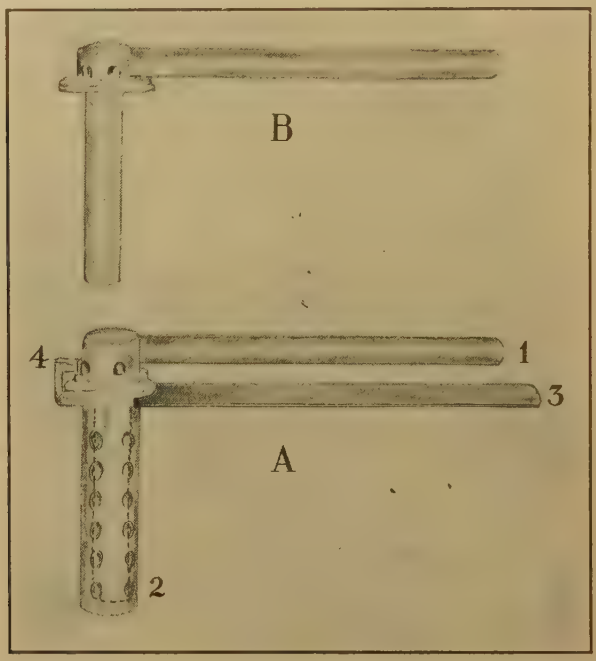

FIG. 173.—*A*. Double metal tube for continuous suction in post-operative treatment. 1. Inner tube with corrugated tapering end to be connected with rubber tube from suction bottle. 2. Short fenestrated outer tube with rounded end to be inserted in the wound. Dotted lines show the position of inner tube. 3. Thin strip of malleable metal, continuous with outer tube, which can be bent to fit the surface of the body. It is held in place upon the skin with strips of adhesive plaster. 4. Hooklike projection on outer tube overhanging flange on inner tube holding the two together.

B. Inner tube removed showing flange, with notch which fits under hook shown in *A*, 4.

still being kept up by attaching a small sized catheter to the sucking apparatus. This catheter is introduced a short way into the vesical lumen.

After-care.—The patient should be made to drink large amounts of water. If the intake does not seem sufficient, or the patient shows any untoward manifestations, such as shock or uremia, continuous instillation of water in the rectum by the Murphy drip will bring great im-

provement in his condition. The patient should have suitable nourishment in generous quantities, should be propped up in bed, and frequently urged to change his position. Within a week, sometimes less, a patient may be allowed out of bed for portions of the day. Meanwhile, the suction apparatus is applied, at the later stages, to the surface of the wound after its final withdrawal from the bladder, say in eight or ten days, thus keeping the patient perfectly dry.

FIG. 174.—(*Watson and Cunningham.*)

Perineal Prostatectomy.—(*Young's Operation*).—Of the several forms of perineal prostatectomy, the method known in this country as Young's is probably the best. A somewhat similar operation is also known as Proust's. The operation as described briefly by Watson and Cunningham is as follows:

"The distinctive features of this technique are: the employment of a special form of prostatic tractor devised by Young, enucleating the gland through two lateral incisions in the fibrous sheath on its posterior surface outside the urethra and parallel with it, and the preservation of the ejaculatory ducts and prostatic urethra. The superficial struc-

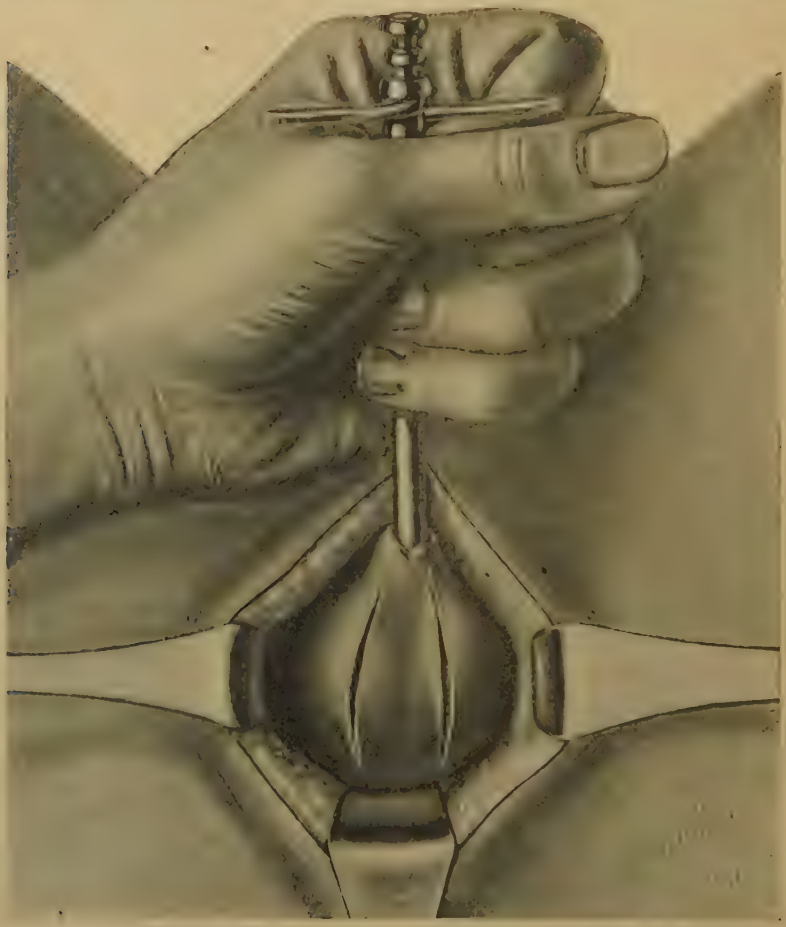

FIG. 175.—(*Watson and Cunningham.*)

tures of the perineum are exposed by an inverted V or Y incision (see Fig. 174. When the membranous urethra has been reached and exposed, it is opened on a grooved staff sufficiently to allow the tractor to be inserted into the bladder (Fig. 175). When it has been entered, its two blades are spread apart and drawn forward against the intravesical aspects of the lateral lobes and the gland is drawn toward the surface

of the perineum, its posterior surface being at the same time tilted upward and thus exposed. The lateral incisions on either side and parallel with the urethra are made through the posterior surface of the fibrous sheath of the prostate. The enucleation is then carried out through each of the incisions in the fibrous sheath in turn, the lateral lobes being thus removed in sequence. The separation of the gland is effected with a blunt dissecting instrument or with the finger tip. The object

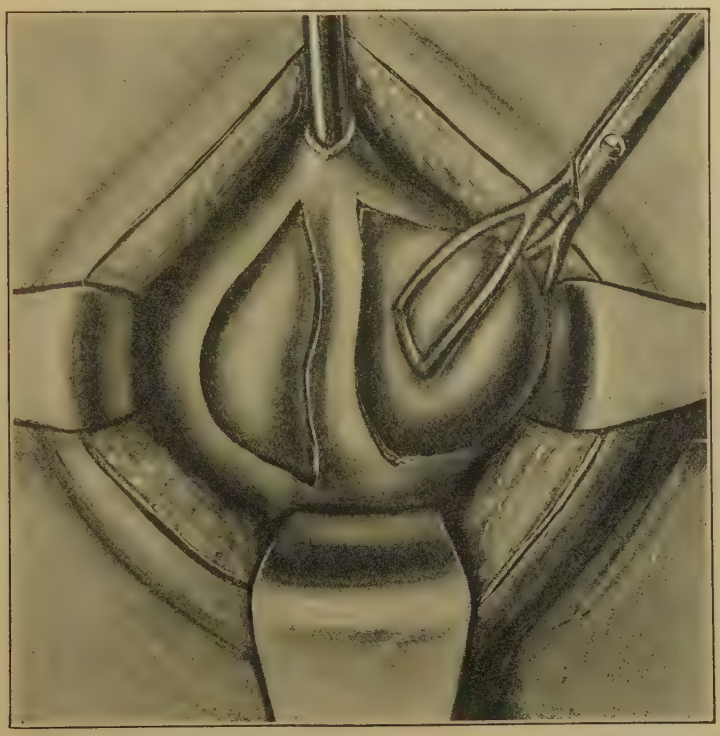

Fig. 176.—(*Watson and Cunningham.*)

of the lateral incisions through the sheath is to avoid injury to the prostatic urethra and the ejaculatory ducts. The external parts of the lobes are freed first. Traction with forceps (see Fig. 176) is made upon the lobes in turn after they have been freed sufficiently to allow the forceps being advantageously placed upon them. The middle lobe, when present, is removed by turning the blades of the prostatic tractor within the bladder so that one of them is engaged behind the farther end of the lobe and then drawing it down and sideways into one of the

lateral pouches left by enucleating the lateral lobe on that side. It is then seized with forceps and enucleated through the same opening in the sheath by which that lateral lobe was removed (see Fig. 177).

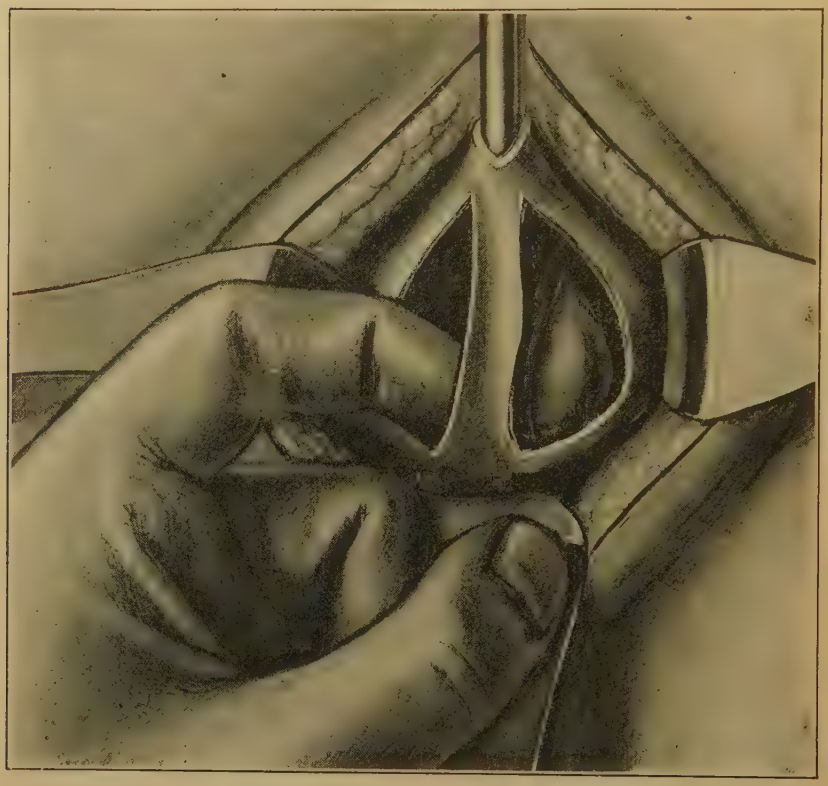

Fig. 177.—(*Watson and Cunningham.*)

The outer wound is closed and the bladder drained by passing a full sized catheter through the urethrotomy opening."

SECTION XV

DISEASES, INJURIES AND DEFORMITIES OF THE EXTERNAL MALE GENITALIA, SPERMATIC CORD AND SEMINAL VESICLES

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URETHRA

Anatomy.—The urethra is a tube of varying caliber which carries both urine and semen. It is about 8 in. in length and is divided anatomically into prostatic, membranous and spongy portions. The prostatic urethra is about 1¼ in. long and extends from the bladder to the posterior layer of the triangular ligament, passing through the prostatic gland. On its floor is located the veru-montanum or collicle. The prostatic urethra is of special clinical interest on account of the many pathological conditions found both in and adjacent to it. Communicating with this part of the urethra is the bladder, the prostatic glands opening through 20 to 30 ducts for the most part in the floor of the urethra, the two ejaculatory ducts, and the sinus pocularis in the veru-montanum. Surrounded by the prostate gland, the caliber, length, and direction of the prostatic urethra may be materially altered by pathological conditions in the prostate. The membranous urethra is about ¾ in. long and passes through the two layers of the triangular ligament by which it is rather firmly held in position. It is encircled by the compressor muscle or voluntary sphincter. The spongy urethra extends from the anterior layer of the triangular ligament to the external meatus, being surrounded in its entire length by the corpus spongiosum of the penis.

Many ducts from urethral glands, the glands of Littre, open into this portion of the urethra. In the glans penis are found several large ducts into which the tip of small instruments may enter, causing difficulty in the introduction of such instruments. Such have been mistaken for strictures. The ducts from Cowper's glands open into the spongy urethra about ½ in. in front of the anterior triangular ligament.

Clinically, the urethra may be divided into an anterior, or erectile portion, in front of the triangular ligament and a posterior, or muscular, portion, including the membranous and prostatic urethræ.

The narrowest part of the urethra is the meatus which acts as a nozzle on a hose, giving the stream its projectile force. This function should not be destroyed by indiscriminate enlargement of the meatus.

The epithelial cells of the urethral mucous membrane are columnar except near the meatus where they are flat or laminated.

Deformities and Malformations of the Urethra.—The urethra may be deformed by some defect of development, whereby the canal is open above (epispadias), below (hypospadias), or is completely closed (atresia).

Atresia is most common at the external meatus, but may be found elsewhere in the urethra. The urethral canal, except the prostatic portion, may be absent, being represented by a fibrous cord. Complete atresia of the urethra demands prompt attention. If the obstruction is located at the external meatus, it can easily be removed, and the meatus kept dilated until healed. When the closure involves a considerable portion of the urethral canal it may be necessary to locate the channel by retrograde catheterization through a suprapubic cystotomy and then open the urethra by means of an external urethrotomy. Congenital closure of the urethra is often associated with a patent urachus.

Hypospadias is a congenital deformity in which some part of the lower wall of the urethra is deficient. The urethra may terminate at any point anterior to the triangular ligament. Even in the absence of the entire lower wall of the anterior urethra the patient still has control of the urine. The most common form of hypospadias is the absence of that portion of the urethra normally located in the glans penis. The urethral orifice in hypospadias is usually small and should be dilated for satisfactory treatment of an infection of the hypospadiac urethra. Accompanying extensive hypospadias there is marked deformity of the penis. The penis may be curved downward, bifid, adherent to, or buried in the scrotum presenting the appearance of a clitoris. If the testicles are undescended and the scrotum bifid the sex may be mistaken in early life.

Treatment.—The simpler forms, limited to the glans penis, require no treatment. For the extreme cases nothing can be done. Some of the penile varieties are amenable to surgical treatment. The outcome in any given case cannot be predicted, yet persistence and repeated plastic operations frequently produce satisfactory results. The operation de-

signed by Beck is to be preferred where the urethral opening is not too far from the glans. His operation consists of dissecting the urethra free for an inch or more and advancing it forward through a tunnel made in the glans, after the skin and membrane of the hypospadiac groove have been incised longitudinally, dissected free and reflected. The orifice of the anterior portion of the urethra is sutured to the edges of the anterior portion of the tunnel through the glans. The reflected skin flaps are replaced and sutured, thus covering the exposed portion of the urethra. For more extensive cases, Rochet's modification of the Nove-Josserand operation for constructing a new urethra from a scrotal skin flap is worth a trial. The flap is left attached at the abnormal urethral opening and is sutured around a catheter. The skin-covered catheter is drawn through a tunnel, which has been made in the hypospadiac portion of the penis. Final sutures are introduced and the catheter allowed to remain in place for eight days.

Epispadias is a deformity where a part or all of the roof of the urethra is absent. Only the urethra of the glans may be undeveloped, or the defect may include the glans and any or all of the penile urethra. In extreme cases there is ectopia of the bladder and no symphysis pubis. Incontinence is common in extensive epispadias.

Treatment.—When the deformity is merely a deep cleft in the glans, it may be closed by plastic flaps. Epispadias accompanied by incontinence makes the patient far more miserable than the most extensive hypospadias. The incontinence calls for surgical treatment, which is always difficult and frequently fails. An inefficient sphincter cannot be restored. A modification of the Nove-Josserand operation for hypospadias may be applied to epispadias where the sphincter is intact.

Traumata.—The urethra may be injured by either internal or external violence. The passage of calculi, foreign bodies and the careless use of instruments may contuse, lacerate or rupture the urethra. Rupture may follow the forcible correction of a "chordee," or violent physical effort taken by a patient who has an urethral stricture. The urethra and its surrounding tissues are damaged by direct external violence, either with or without rupture of the skin. Very extensive damage of the urethra may follow traumata of the perineum with but little external evidence. Every instrument introduced into the urethra must be manipulated with extreme care and gentleness; patience while using instruments is not only a virtue but a positive duty. Serious, even fatal, results have followed rough and unskillful use of urethral instru-

ments. What cannot be accomplished by careful, gentle and skillful efforts, certainly cannot be accomplished by force.

Symptoms.—Minor contusions and abrasions of the urethra cause only a slight feeling of soreness at the site of the injury, more noticeable during urination. A little blood may come with the first urine. More extensive injuries are followed by swelling, pain and pronounced hemorrhage. When the urethra has been injured by external violence, the swelling usually appears within a few hours and is associated with pain and retention of urine. Rupture of the urethra consequent to a stricture causes severe pain, yet the swelling appears slowly. The patient has chills followed by fever. In both instances there has been extravasation of urine.

Treatment.—The simpler injuries require no treatment other than sexual sedatives and alkalies internally to render the urine non-irritating. Penetrating wounds of the urethra should be exposed and sutured over a retention catheter. Complete rupture of the membranous urethra should be repaired through a perineal section. The distal end is easily found by introducing a catheter through the penis. If careful search for the proximal or bladder portion fails it becomes necessary to open the bladder suprapubically and pass a catheter from behind. Retaining sutures are placed in the proximal portion of the urethra as guides, the catheter is removed from the bladder and the catheter in the penile urethra is passed through the posterior urethra into the bladder. The divided ends of the urethra are approximated and sutured with fine catgut. Drainage is provided in the perineal incision. The catheter should remain in the urethra from 8 to 10 days, after which a sound ought to be passed at intervals. Severe injuries to the urethra involving the bulbous part of the corpus spongiosum may be followed by the loss of penile erections. In one of the author's cases where the bulbous urethra together with the surrounding tissues had been extensively lacerated, and was operated on within five hours of the injury, there was complete primary union of the urethra with no perineal leakage, yet four months elapsed before penile erections were noticed and these were not perfect as the corpus spongiosum did not participate. At the end of two years, erections are normal, excepting the glans penis which never becomes engorged.

Extravasation of Urine.—Extravasation of urine occurs when the urethral wall has been ruptured. The impairment to the urethra may be the result of traumatism, or may be produced by the act of straining at urination when there is some obstruction to the outflow of urine, *e.g.*,

a foreign body, a calculus, or a stricture. It may follow the careless introduction of urethral instruments.

Symptoms.—A considerable quantity of blood may flow from the urethra, attended by pain, and later by chills and fever. Extravasation following perineal injuries or urethral instrumentation, causes a perineal tumefaction within a few hours, which, if not given prompt surgical attention, rapidly extends to the scrotum and on to the anterior abdominal wall. Inability on the part of the patient to empty the bladder is a frequent complication which must be relieved. Extravasation resulting from a stricture of the urethra develops more slowly, usually becomes infected and may present as a perineal abscess which leaves a perineal urinary fistula. Extensive sloughing of the perineum, scrotum, penis, and abdomen may result from neglect.

Treatment.—To be successful, treatment should be instituted early. Abscesses must be opened as soon as recognized. Free incisions over extravasated areas relieve the tension and may prevent sloughing. Temporizing has cost many lives. Early drainage is most important, after which applications of warm, moist, antiseptic dressings are helpful. Sloughing of the scrotum with exposure of the testicles seldom calls for a plastic operation later, as one would suppose. If the parts are kept clean, nature will form a new and comfortable scrotum from the contiguous skin.

Inflammations.—Urethral inflammations are characterized by urethral discharge. Gonorrhea is the most common infection of the urethra. Many other varieties of urethral infection must be borne in mind if serious mistakes and embarrassment would be avoided. Every urethral discharge should be subjected to a careful bacteriological examination. Especially is this true in cases in which some medico-legal question may arise.

Urethral discharges are classified as either non-infectious or infectious. Non-infectious discharges from the urethra may be caused by (1) constitutional conditions such as protracted fevers, acute exanthemata, (2) excessive sexual excitement, with or without gratification, (3) drugs or food, (4) careless instrumentation and injections of strong solutions of irritating chemicals or drugs, (5) foreign bodies, calculi, neoplasms and strictures. The infectious discharges are produced by (1) chancroids, (2) syphilis, (3) tuberculosis, (4) simple bacteria, (5) micrococcus catarrhalis, (6) the gonococcus.

Symptoms.—Non-infectious discharges from the urethra are accompanied by few symptoms other than the discharge which is scant, mucoid,

not deeply colored, but may contain epithelial cells and blood. Chancroidal infection of the urethra is rare, is limited to the region of the external meatus, and is characterized by the rapid destruction of tissue and by a foul-smelling, sanguineous discharge.

Intraurethral chancres occur just within the meatus and are sometimes mistaken for gonorrhœa. The discharge is seropurulent, attended with localized pain and difficult urination. An induration may be felt which must not be treated as a stricture. A history of exposure to infection, the period of incubation, three to five weeks, the induration and the seropurulent discharge are strongly suggestive of a beginning luetic infection. Demonstration of the spirochæta pallida, a positive Wassermann reaction, or the secondary symptoms of syphilis establish the diagnosis.

Tuberculosis of the urethra is also rare, is secondary to tuberculosis elsewhere in the genito-urinary tract, causes great pain and produces but little discharge. The finding of tubercle bacilli in smears obtained from urethral ulcers or infiltrations or tubercles seen through the urethroscope are positive evidences of tuberculosis of the urethra.

Non-specific Urethritis.—An invasion of the urethra by the simpler forms of pyogenic bacteria frequently follows the use of unclean sounds or catheters, or may develop after coitus with an unclean woman. The period of incubation is short, one or two days, after which there appears a scant, light colored urethral secretion attended by increased frequency of, and painful urination. Altogether the symptoms are suggestive of a mild gonococcic infection, yet no gonococci are found on microscopic examination. If the treatment is not too heroic the symptoms subside and the discharge ceases in from 7 to 14 days.

Micrococcus catarrhalis while not a frequent cause of urethral inflammation is a most important one. It may be the disturbing agent in some cases of urethritis where the patient has not been exposed to venereal infection. The morphology of these cocci varies slightly from the gonococci in that they are larger, more rounded and are found in greater numbers. The micrococci catarrhalis are extracellular until near the end of the course of the disease, when they are practically all intracellular. It is impossible to make a positive differentiation between the micrococcus catarrhalis and gonococcus from a microscopic examination alone. Since no differential stain has been found, we must depend upon culture. The micrococcus catarrhalis will grow on nutrient agar at ordinary temperature, while the gonococcus will not. The colonies develop in from 24 to 36 hours. If gram-negative diplococci

are found in this growth the diagnosis is M. catarrhalis. If none are found in the culture although present in the urethral discharge, the case is one of gonorrhœa.

Gonorrhœa.—About 95 per cent. of all urethral infections are caused by the gonococcus (Neisser's diplococcus). As it is estimated that 80 per cent. of the male population is infected with this germ, before 30 years of age, its prominence as a pathological factor is at once apparent. The conjunctiva is particularly susceptible to gonorrhœal infection, much less so are the mucous membranes of the nose, mouth and rectum.

Gonococci appear in pairs (diplococci) resembling two coffee beans, with their flat surfaces apposed. They are readily stained with methylene blue, gentian or methyl violet and are discolored by Gram's solution. After the specimen is carefully stained it should be examined with an oil immersion lens ($\frac{1}{12}$) as the narrow line between the two halves cannot be seen through low power lenses. Cultures of gonococci grow best on sterile hydrocele and human blood serum. Because of their slow growth it is difficult to obtain cultures free from pyogenic bacteria. As many as twelve different strains of gonococci have been isolated and cultured, an important factor in the preparation of gonorrhœal vaccines. The period of incubation is from 2 to 16 days, average time in first attack 3 to 7 days, in recurrent attacks 1 to 5 days. While simple urethral inflammations may develop from many causes, gonorrhœal inflammation is due to a gonococcic infection obtained usually from one of the opposite sex who is harboring these organisms. Thirty-six to 40 hours after the inoculation, the gonococci begin to find their way between the epithelial cells. At this time there is a tickling, itching sensation in the urethra which is soon followed by a thin serous discharge. Microscopic examination shows only a few extracellular diplococci. At the end of the third or fourth day pus appears, as large numbers of bacteria have invaded the epithelial spaces and myriads of leucocytes have crowded in from the subepithelial spaces to combat the enemy and protect against further invasion. A thick yellowish discharge now presents, and there is a burning sensation on urination. At this stage the patient may have a chill followed by high fever, evidences of a general toxæmia. The discharge abounds in pus cells, many of which contain 12 to 20 diplococci. Large flat epithelial cells are also numerous. As the pus cells and the gonococci increase, the number of the epithelial cells decrease, until the declining stage of the disease when the discharge is thin and scant, the gonococci and pus cells are few and there is again an increased number of epithelial cells.

Extension to the lymphatics may cause preputial œdema, phimosis and paraphimosis, or inguinal adenitis (bubo).

When the inflammatory process extends beyond the mucous membrane and involves the erectile tissue of the corpus spongiosum it interferes with the distention of the areolar spaces during erections and the penis is bent downward, a condition known as *chordee.* Chordee should never be forcibly straightened, for by such an act the urethra may be

FIG. 178.—Gonorrheal osteoma on os calcis. (*Author's case.*)

torn, causing marked hemorrhage, urinary extravasation and later cicatricial narrowing of the channel (traumatic stricture).

The infection travels toward the posterior urethra by continuity of surface and contiguity of tissue. Owing to the paucity of mucous glands in the narrow membranous urethra, the march of the army of gonococci is here halted. Yet in a considerable number of cases the posterior urethra becomes infected. Posterior urethritis seldom develops before the end of the third week of the acute anterior urethritis.

The patient happy in the belief that he is almost cured, suddenly experiences painful and frequent urinations. Marked strangury is attended by the appearance of blood either before or at the end of urination. In very severe cases the patient may suffer retention of urine. The infection is seldom limited to the posterior urethra. It frequently follows one or more of the avenues leading from the posterior urethra and may involve the bladder, kidneys, verumontanum, prostate, seminal vesicles, or the epididymes. Gonococci have been carried to remote parts of the body, such as the joints, pleural cavity and middle ear. *Gonorrhœal exostoses* may develop, particularly on the plantar surface of the os calcis (Fig. 178). When present, the patient suffers severe pain while standing, and has a peculiar gait, due to his attempts to favor the heels in walking. Diagnosis is made from the history and from radiographic findings. If the pain does not subside after several weeks of rest and relief from pressure, the exostoses should be removed surgically.

Treatment of Urethral Inflammations.—Non-infectious inflammations require but little treatment other than removing the cause (neoplasms, foreign bodies, calculi). Rest, bland diet, alkali drinks, hasten a restoration to normal.

A few applications of the Oudin high frequency current will arrest the progress and lead to healing of those cases of urethral chancroids that have not responded to the usual antiseptic treatments.

Intraurethral chancres yield to proper antisphilitic treatment. Simple bacterial infections are inclined to a short self-limited course, if not treated too vigorously. Mild antiseptic and astringent urethral injections three to four times daily will suffice.

Infections due to the micrococcus catarrhalis should never be treated with solutions of silver salts. Santal wood oil internally with very mild urethral injections will cure most cases in from 7 to 21 days. Injections of strong solutions of irritating drugs convert a comparatively simple trouble into a protracted, stubborn condition which tries the patience of both patient and surgeon.

The treatment of gonococcic infections is prophylactic, abortive, and curative. Preventive or prophylactic treatment consists in wearing a condom when having coitus or in the injection of 5 to 10 drops of a 2 per cent. solution of protargol just within the external meatus immediately after intercourse. This is to be retained at last 10 minutes. The external parts must be cleansed with an antiseptic solution.

Abortive treatment to be of value must be applied within 24 to

36 hours after the first symptoms are noticed and before the infection has penetrated the subepithelial structures. Thirty drops of a 5 per cent. argyrol solution or the same amount of a 2 per cent. protargol solution introduced and held in the anterior urethra for 15 to 20 minutes twice daily often produces the desired results.

A better method, the one suggested by Ballinger, is to seal 25 drops of a 5 per cent. solution of argyrol in the urethra with collodion and keep it there for six hours. This is repeated on the second and third day and if successful there is no more discharge and no gonococci can be found. If the disease has not been aborted in three days, this method of treatment is discontinued and no harm has been done. About 80 per cent. of all cases treated in this manner not later than 36 hours after the appearance of first symptoms are cured with from one to three treatments.

Patients not seen this early but who have an acute anterior urethritis should have copious anterior irrigations of a solution of protargol, ¼ per cent., albargin solution 1–3000, or argyrol 5 per cent. solution two or three times a day. The patient is given a hand injection of a very mild silver solution to be used and retained for three to five minutes after each urination. The diet should be bland. Alcohol, tobacco, sexual excitement and violent physical exercise must be avoided. Three to five weeks of this treatment will cure most cases if the infection has remained anterior. Unfortunately, regardless of treatment, a great many cases of anterior urethritis are complicated by an involvement of the posterior urethra within three or four weeks. Janet's method of irrigating the urethra with large quantities of warm solutions of permanganate of potash 1–8000, or silver nitrate 1–15,000 proves most efficacious when used two or three times daily in acute posterior urethritis. Small doses of morphia and atropine will allay the strangury and tenesmus.

Complications of urethral infections are periurethral abscess, cowperitis, colliculitis, prostatitis, seminal vesiculitis, epididymitis and arthritis. Uncomplicated chronic gonorrhœal urethritis should be treated with silver solutions, stronger than those used in acute urethritis, and with irrigations of astringent solutions. Granulomata should be curetted through the urethroscope or destroyed with silver nitrate stick, applied topically through the urethroscope. Vaccines containing gonococci, staphylococci and colon bacilli are of value in the treatment of some cases, especially where there is chronic prostatitis, vesiculitis or arthritis present.

Periurethral abscess, Fig. 179, may develop early in an infection of the anterior urethra. If the abscess does not rupture spontaneously into the urethra it should be opened externally.

Affections of Cowper's Glands.—Cowper's glands, two in number, lie between the two layers of the triangular ligament and are surrounded by the compressor urethræ muscle. Each gland communicates with the bulbous urethra through a small duct about 1 in. in length. Gonorrhœal infection of Cowper's glands though rare, may develop aa early as the third week of an acute gonorrhœal urethritis.

FIG. 179.—Periurethral abscess of gonorrheal origin.

During the inflammatory stage there is pain and perineal tenderness. The gland is best examined bi-digitally with the forefinger just within the anal sphincter and the thumb of the same hand on the perineum. The normal gland can seldom be felt. The inflammation may subside or it may go on to abscess formation. An abscess in Cowper's gland causes severe pain, fever and perineal swelling with difficult urination or retention.

The abscess may rupture into the urethra, the rectum or the perineum. A perineal urethral fistula is a frequent complication.

Treatment.—Acute inflammation of Cowper's glands should be treated with hot moist applications to the perineum, hot sitz baths, free catharsis and anodynes when pain is severe. If there are evidences of abscess formation, perineal drainage should be instituted before

rupture into the urethra occurs. Early evacuation of the pus externally may prevent a urinary fistula. The external drainage should be continued as long as pus is present.

Cases that have ruptured spontaneously may need a curettement under general anæsthesia before the pus cavity is entirely destroyed. Persistent pus formation with a communication between the urethra and the abscess area or an urethro-perineal fistula must be treated surgically by a radical removal of the abscess cavity and an external urethrotomy along the fistulous tract.

Tuberculosis of Cowper's glands is secondary to tuberculosis elsewhere in the urinary tract. The symptoms of pain and swelling appear insidiously and are not so severe as in gonorrhœal infection of the glands. Tuberculosis of Cowper's glands is best treated by complete removal of the gland involved.

Cancer of Cowper's gland is exceedingly rare, has the usual symptoms of malignancy and should be removed early.

Urethroscopy.—With the perfected urethroscope came new revelations of pathological conditions in the urethra. Diagnosis and treatment of hitherto unknown and unrecognized conditions became possible. The value of this instrument is in direct proportion to the familiarity of the operator with both normal and abnormal urethræ. The surgeon experienced in the use of the endoscope, and the irrigating cystourethroscope will not allow any urethral lesions to escape his notice. With the aid of these instruments, there can be recognized and treated, chronic inflammation of the urethra, infected follicles, granulomata, papillomata, cysts and colliculitis. Foreign bodies and calculi can be located and removed.

Stricture of the Urethra.—Stricture of the urethra is an abnormal narrowing of some part of that channel, which interferes with the free outflow of urine and is due either to muscular spasm or to organic changes in the walls of the urethra. Congenital constriction is most common at the external meatus, but may be in the posterior urethra; it must be dilated, after which its disagreeable symptoms usually disappear. A certain amount of narrowing of the external meatus is normal and favors the projection of a strong stream. Therefore, division of a narrow meatus must be done very carefully and conservatively.

Acquired strictures are either spasmodic, congestive or organic.

The spasmodic stricture is either reflex or psychic, and is usually due to an irritable compressor urethræ muscle. Among the causes are acid urine, hemorrhoids, pin-worms. It is particularly apt to occur in

young men who are the counterpart of hysterical women. A single catheterization may give immediate and permanent relief.

Congestive stricture is due to inflammatory swelling of the urethral mucous membrane and frequently occurs during the acute stage of gonorrhœa. If the retention is complete it is usually associated with a spasm of the compressor urethræ muscle. These conditions which are classified as spasmodic and congestive strictures are temporary obstructions and not true strictures.

Most frequent and most important is the *organic* stricture, where there are actual changes in the wall of the urethra, forming a narrowing and rigidity. Sir Charles Bell has described it as a condition in which the affected portion of the urethra has lost its normal dilatability.

Organic strictures may follow any severe traumatism which causes rupture of the urethral wall, the resulting scar narrowing the channel. A large percentage of all organic strictures are secondary to gonorrhœal urethritis. Stricture may follow repeated attacks of urethritis, or a long-continued chronic urethritis. It seldom occurs before two years have elapsed since the original attack of gonorrhœa and may not give the patient much inconvenience for 10 or 12 years.

The popular idea that a rapid cure of gonorrhœa causes stricture is not based on facts. On the contrary, the longer the duration of the inflammation, the more liable is the patient to have a stricture. It is the exception for a urethra to become normal after even one prolonged attack of chronic inflammation.

The pathological process of stricture formation is that of cell infiltration and connective-tissue formation.

The most common site of stricture is in the bulbo-membranous urethra, but it may occur near the external meatus. The great vascularity and the numerous glands and follicles in these regions necessarily form a fertile field for chronic urethritis and thus predispose to stricture. Gonorrhœal strictures are exceedingly rare in the prostatic urethra.

The urethra behind a stricture becomes dilated, the pouch thus formed being a most excellent receptacle and incubator for the germs of sepsis. Thinning of the wall and ulceration may lead to rupture of the urethra, extravasation of urine and periurethral abscess which tends to rupture externally, forming a urethral fistula. This fact argues for the early treatment of stricture. In long-standing, neglected cases the bladder takes on a compensatory hypertrophy as a result of repeated forcible efforts to empty itself through a narrowed outlet. Cystitis may de-

velop, followed by involvement of the ureters and an infection of one or both kidneys (ascending pyelonephritis).

Symptoms.—In their incipiency, strictures produce but slight disturbance. The intelligent man observes that it takes him slightly longer to urinate than formerly. As the stricture increases and the lumen of the urethra diminishes, the bladder is never entirely emptied, hence micturition is more frequent than normal. Micturition is not very painful, except in the extreme cases where the patient strains violently to force the urine through the narrowed channel. A forked, twisted stream is not characteristic of stricture.

Dribbling after urination is due to a few drops held behind the stricture, escaping after the bladder has emptied itself. This occurs as a comparatively early symptom. Dribbling from an over-distended bladder due to stricture is a very late symptom, and is worse during the day while the patient is up and about. Sudden complete retention may develop, the patient being unable to pass even drops of urine. This is due to an engorgement of the mucous membrane over the stricture and may follow exposure to cold, the excessive use of alcohol or sexual excesses.

In order to save the patient a great deal of trouble, and to avoid serious complications, it is necessary to recognize stricture in its earlier stages. When there is a gleety discharge, increased frequency of micturition, dribbling after urination, and more or less hypogastric pain, an examination for stricture should be made.

In examining for stricture it must be borne in mind that spasm of the urethra is not a stricture. Any instrument that will pass through the external meatus should without difficulty pass through the rest of the normal urethra. In order to ascertain the presence of a stricture, the first instrument to be used should be as large as the external meatus will admit readily. The possibility of doing damage to the urethra and of creating a false passage, is far less with a large instrument than with a small one. *Force must not be used* in passing a sound or any instrument through the urethra. If the first instrument tried does not readily pass, try a smaller one, and so on until one is found that will pass. It is a wise plan for all who are not especially skilled in the use of sounds and bougies to refrain from the use of small metal instruments. The small inflexible bougies, even in the hands of the unskilled, will at least do no harm and are often of great service. Olive-tipped bougies (bougies-a-boule) are most serviceable aids in diagnosing and locating urethral strictures.

Treatment.—The treatment of organic stricture is both general and local.

General Treatment.—Special attention should be given to hygiene. The diet should be bland and not stimulating. Alcohol and tobacco are to be forbidden, sexual excesses and exposures to cold and wet must be avoided. Alkalies internally to neutralize the urine are beneficial.

Local treatment consists in using measures to overcome the abnormal narrowing of the canal and to restore as nearly as possible the normal dilatability of the urethra. These objects are best accomplished by gradual and intermittent dilatations. About 98 per cent. of all cases will yield to this treatment, when properly executed. The passage of a sound through a stricture not only acts in a mechanical way by increasing the caliber of the urethra, but it stimulates absorption, of the inflammatory product. If too much be done at one treatment, the mucous membrane is damaged and this may produce more swelling and inflammation and defeat the very purpose of the treatment. In the beginning of the treatment sounds should be passed every three to four days. When a sound as large as 18 F. passes easily, once a week is often enough; later, the passage of a sound once a month and finally two or three times a year suffices.

All instruments must be surgically clean. They should be warm and well lubricated before being used. If the patient is very nervous, it is quite helpful to give him 20 grains of sodium bromide and five grains of chloral about one hour before sounds or bougies are passed. It also facilitates matters in old multiple strictures to give the patient a sitz bath for 20 minutes just prior to the treatment.

While a sound is being introduced the penis must be held vertical and kept well on the stretch, so as to obliterate the mucous folds of the urethra as much as possible. Probably the most common error in the use of metal sounds is to think that the tip of the instrument is engaged in the opening of the triangular ligament before it really is. The handle is depressed too soon, thus forcing the instrument through the roof of the urethra, and making a false passage.

When the stricture has been reached, the proximal end of the sound, grasped lightly between the surgeon's thumb and forefinger, should be manipulated with the greatest gentleness, very much like a probe. Sometimes the tip of the sound may be guided by a forefinger making pressure on the perineum, or introduced into the rectum.

Very tight strictures test the skill and patience of the surgeon. No stricture should be condemned as impermeable so long as urine escapes,

even though it be merely by drops. If the smaller sounds do not pass, try filiforms. If the first filiform does not pass, leave it in place and introduce a series of others alongside it, until one finds its way through. As many as 12 or 14 may be necessary before one slips through. Before attempting to pass the filiform, there should be instilled deep into the urethra 10 drops of a 2 per cent. novocain solution to which has been added five drops of a solution of adrenalin chloride (1–1000). This will lessen the irritability of the urethra and diminish the vascularity of the parts. Wait five minutes, then inject enough warm sterilized olive oil to balloon the urethra. If great difficulty has been experienced in passing the first filiform, leave it *in situ* for 24 hours, after which gradual dilatation may be continued.

Impermeable strictures will frequently become permeable after suprapubic bladder drainage for several days. Such a drainage can be introduced through the canula of a trocar. This should be tried in preference to attempting a perineal section without a guide.

It is well to bear in mind the complications that may attend the passage of sounds. If the patient is of a neurotic temperament he may become collapsed from the shock. When this occurs, give 30 drops of aromatic spirits of ammonia and keep the patient quiet for 24 hours.

The passage of a sound sometimes produces a condition known as *urethral* or catheter fever. The severity of this condition varies from a slight rigor to a distinct chill followed by fever and the symptoms of acute sepsis. It may pass off in a few hours, or may incapacitate the patient for several days, or even prove a very serious and dangerous complication. As a prophylactic measure against urethral chill it is well to give 10 grains of quinine sulphate with five drops of the tincture of aconite, one-half hour before instrumentation. False passages will not be made if no force is applied while introducing urethral instruments.

Epididymitis occasionally, though seldom, follows the passage of a sound.

Internal urethrotomy is not to be recommended except in the hands of those skilled in genito-urinary surgery, because of the obscurity of the field of operation and the possibility of doing great damage.

The indications for perineal section (external urethrotomy) in the treatment of strictures are few. The most imperative is in stricture due to trauma. Early excision of the fibrous tissue found in traumatic strictures is usually followed by permanent good results.

Irritable resilient strictures in the bulbo-membranous region, in which every attempt at instrumentation causes severe pain, require an

external urethrotomy, with free division or excision of the fibrous bands. Long-standing multiple strictures of small caliber which do not yield to dilatation should be incised through an external or perineal incision before periurethral abscess and fistula form. Strictures complicated by fistula and severe cystitis should be treated by perineal section after dilatation and irrigation have proved inefficient.

In some cases of sudden and complete retention of urine, due to acute congestion of the mucous membrane over stricture bands, it is very difficult and at times impossible to enter the bladder *per urethram*. Never give a patient suffering from such a condition a general anæsthetic as his struggles may cause rupture of the over-distended bladder. A trocar can easily be introduced into the bladder above the pubes, under local anæsthesia, and the tension relieved. After a few days it is often easy to enter the bladder *per urethram*. If not, the patient may be given a general anæsthetic without the danger of rupture of the bladder, and an external urethrotomy performed.

Urethral Neoplasms.—Before the development and more general use of the urethroscope, urethral neoplasms were believed to be rare.

Papilloma is the most frequent variety of new growth in the urethra. It is found in the anterior and prostatic portions of the urethra, rarely in the membranous urethra. Seen through the urethroscope, papillomata appear as small, sessile or pedunculated, fungating growths attached to the urethral wall. They bleed easily and may be large enough to cause some obstruction to the outflow of urine.

Symptoms of Papilloma.—The symptoms of papilloma are thin, scanty urethral discharge, resembling that due to chronic urethritis; bleeding especially after the introduction of urethral instruments; a slight burning sensation in the urethra during urination and increased frequency of micturition. A case of chronic masturbation was cured when a small papilloma was removed from the posterior urethra (author's case). Diagnosis is possible only with the aid of the urethroscope, through which the tumors can be seen.

Treatment.—Most patients with urethral growths have been treated over a long period for gleet, stricture or chronic gonorrhœa. Complete removal is the only proper treatment. This can be accomplished through the urethroscope by means of silver nitrate in small growths, and the electro-cautery or high frequency current when the masses are larger.

Cysts of the urethra are not frequent and their symptoms are almost the same as those of papillomata except that bleeding is absent. They are found when examining with the urethroscope and appear as thin,

almost translucent sacs protruding from the urethral wall. Oudin's high frequency current, or puncture followed by topical applications of the tincture of iodine to the interior of the cyst will destroy the sac.

Primary malignant disease of the urethra is rare. However, enough cases have been reported to warrant the surgeon in keeping in mind the possibility of primary sarcoma and carcinoma of the urethra. Malignant growths are usually secondary to similar lesions of the penis, bladder or prostate gland.

Malignant disease of the urethra does not differ from the same disease elsewhere and should be treated radically by early and complete removal.

Urethral Fistula.—Fistula of the penile urethra frequently follows a periurethral abscess. Rarely does such a fistula close spontaneously

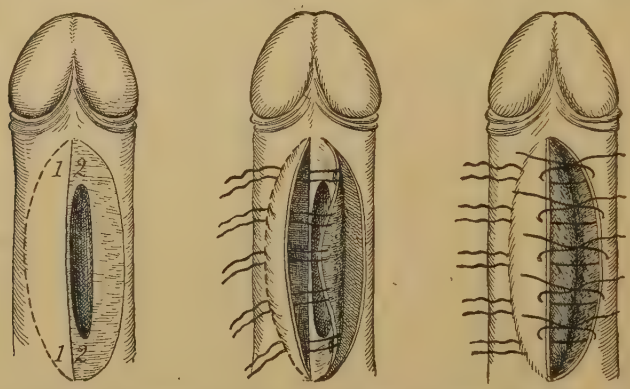

Fig. 180.—Szymanowski's operation for a large fistula. (American Text-book of Genito-urinary Diseases, Syphilis, and Diseases of Skin.)

or even when encouraged by the use of local stimulants, such as silver, iodine, or electricity. Skillfully made surgical attempts to close urethral fistulæ are not universally successful.

Szymanowski's modification of Thiersch's urethroplasty (Fig. 180) has proven to be quite satisfactory. In this operation an incision is made from just beyond one end of the fistula, continued on the right of the muco-cutaneous border of the fistula, to a point beyond the other end of the fistula. An elliptical skin-flap is dissected to the right, which forms a pocket for the reception of a similar flap dissected from the opposite side but left attached to the border of the orifice of the fistula. The second flap is turned over the fistula and its free border sutured with fine silk to the bottom of the pocket. The free border of the first flap is then sutured to the margin of the skin from which the second flap was taken.

Perineal drainage must be established and continued until healing of the flaps is complete. Small fistulæ may be cured by diverting the urine stream from the urethra by means of a perineal drainage and then treating the fistulous tract by means of caustics or high frequency current applied through a wire electrode inserted into the tract.

PENIS AND PREPUCE

The penis is made up of three bodies of erectile tissue, viz., the two corpora cavernosa and the corpus spongiosum, held in place by a fibrous sheath and covered by a thin freely movable investment of skin. The corpora cavernosa are placed parallel to each other in the upper part of the organ, separated from each other by a porous septum. The corpus spongiosum lies in the groove between and below the corpora cavernosa; it forms the bulb of the penis posteriorly and the glans anteriorly. The urethra passes through the entire length of the corpus spongiosum.

The integument covering the organ is reflected back at the glans and forms the prepuce. The inner surface of the prepuce is lined with mucous membrane continuous with that covering the glans penis. The frenum is a fold of mucous membrane on the under surface of the glans. The frenum may be lacerated during coitus and is often destroyed by chancroidal ulcerations. Injury to the frenum may be followed by profuse hemorrhage due to rupture of the artery of the frenum.

The arterial blood supply of the penis is from branches of the internal pudic artery. On the dorsum of the organ are found two arteries and one vein. The vein carries the blood for the most part to the prostatic plexus of veins. The nerve supply is from the internal pudic nerves and the hypogastric plexus.

The lymphatics from the glans, prepuce, the penile integument and the anterior urethra pass to the inguinal region; the other lymphatics communicate with the lymphatic system of the deep pelvis. Superficial infections are carried to the inguinal region, while malignant disease of the penis may involve both the inguinal and deep pelvic lymphatic glands.

Congenital Deformities.—Congenital deformities of the penis are usually associated with other physical malformations and mental deficiency. The penis may be absent; concealed beneath the surface; abnormally large as in imbeciles and the intellectually deficient; double or adherent to the scrotum.

Injuries of the Penis.—Although the penis is an external organ it is seldom injured. The degree of injury varies from a simple contusion to complete destruction. Slight wounds or superficial injuries of the penis produce but slight symptoms and are to be treated with antiseptic dressings. The more severe injuries are accompanied by hemorrhage and more or less priapism, to be followed later by loss of erectile power. This is especially true when the deeper penile structures have been damaged. Sexual disability, resulting from a wound or injury, is frequently accompanied by a change of the individual's disposition. He may become despondent and melancholic.

Treatment.—The treatment of injuries of the penis should be conservative. Stop the hemorrhage, apply moist antiseptic dressings and control erections with bromides, chloral and camphor. If the urethra has been ruptured it should be treated as suggested in the discussion of that subject. Amputation of the penis for wounds or injuries should be a matter of last resort, as ofttimes the most discouraging cases recover satisfactorily, owing to the liberal blood supply of the organ. Boys and the feeble-minded sometimes place rings, strings or rubber bands on the penis sufficiently tightly to cause strangulation. Swelling develops rapidly and if the constriction is not quickly released gangrene may follow.

Prepuce.—The normal prepuce covers the glans penis and may be easily retracted. In *phimosis* the foreskin cannot be retracted. This condition may be congenital or acquired. In *congenital phimosis* the preputial orifice may be so small that urination is difficult. There may be ballooning of the prepuce with urine. Every newborn male child should be carefully examined by the attending accoucheur. If the preputial orifice is narrow and the prepuce adherent to the glans, the orifice should be dilated and adhesions destroyed. The nurse should be instructed to retract the prepuce daily and after cleansing the parts apply a small amount of sterile vaseline, which will prevent the formation of other adhesions. A little later, if there is a tendency to a persistence of the trouble, circumcision should be performed.

Acquired phimosis is produced by an acute inflammation with œdema of the prepuce. The causes are uncleanliness, urethritis, chancers, chancroids and malignant disease. Frequently there is associated with the phimosis a destructive ulceration, concealed beneath the prepuce, characterized by a copious discharge of greenish yellow, foul smelling pus. If a hard chancre be present it can be felt through the foreskin. Unless there is mixed infection, the discharge from such a

lesion is not great and is not particularly offensive. In hospital and clinical practice it is not uncommon to find acquired phimosis accompanying gonorrhœa, chancres, chancroids, and a most conspicuous absence of cleanliness. Phimosis due to the simpler infections will usually respond promptly to frequent cleansing with mild antiseptic solutions and the application of dressings kept moist with a solution of aluminum acetate, or the lotio opii et plumbi. The more aggravated and neglected cases must be promptly relieved by splitting the foreskin freely either by a single incision on the dorsum, or by two lateral incisions. Circumcision may be performed later, when the active infection has been overcome. Very extensive destruction of the glans penis is often found in c ases of mixed infections. Heroic treatment is here necessary to prevent further destruction of the parts. The application of crystals or tablets of bichloride of mercury in the same manner that the silver nitrate stick is used, has proven very efficacious.

The mercury crystals or tablet must not be applied more frequently than once in 48 hours. During the interval moist antiseptic dressings should be used. A few treatments with the high frequency spark from a copper wire electrode have also been satisfactory in the most obstinate cases.

In *paraphimosis* the prepuce is retracted behind the glans and cannot be brought forward. If the constriction thus formed is not soon released marked œdema of the glans and prepuce rapidly follow. Neglected cases may result in gangrene. Early cases of paraphimosis may be reduced by making traction on the foreskin with simultaneous pressure on the glans. Later it may be necessary to incise the constricting portion of the prepuce which can be done under local anæsthesia.

Malignant disease limited to the prepuce is rare and when it occurs differs in no way from skin cancer elsewhere.

Circumcision.—Circumcision is indicated for persistent congenital phimosis, in cases of redundant foreskin in which it is difficult to maintain cleanliness and in some badly infected cases. In the very young no anæsthesia is necessary. Older patients can be circumcised without pain by the proper use of local anæsthesia. Cocain in ½ per cent. solution freshly prepared and sterile, or novocain 1 to 2 per cent. solution are the best preparations for this purpose. A constricting band is applied around the body of the penis before the anæsthetic is introduced. With a sharp thin hypodermic needle the solution is introduced *into* the skin back of the glans, completely encircling the penis. If the prepuce can be retracted the mucous surface may be treated in the same

manner, thus making the anæsthesia complete. Where it is impossible to retract the foreskin a pledget of cotton saturated with a 10 per cent. solution of cocain should be pushed under the foreskin into the sulcus behind the glans and allowed to remain 10 minutes. This will anæsthetize the mucous membrane. A much simpler method and one that does not produce œdema of the tissues is to introduce six drops of the anæsthetic solution into the body of the penis at four points, the dorsum, the ventrum, and each side. Care must be taken not to introduce the needle too far. Fully 15 minutes are required to establish complete anæsthesia by this method.

Circumcision is usually considered both by the laity and the profession as a very simple and trivial operation. The mere fact that many methods of operating have been advised is proof that removal of the proper amount of foreskin, neither too much nor too little, is not an easy and certain procedure. The muco-cutaneous border of the prepuce should be grasped with a mouse-toothed hemostat above and below. The skin is drawn forward until it is fairly taut. A clamp is applied not at right angles to the long axis of the penis, but parallel to the dorsal surface of the glans. A sharp knife is drawn through the skin along the outer surface of the clamp. The clamp is removed and the small arteries ligated with fine catgut. The skin is retracted and the cuff of mucous membrane reflected, so that the cut edges of both are in apposition where they are sutured with six or eight interrupted sutures. After the sutures are tied, the ends are left long for the purpose of holding in place a small band of gauze dressing.

Herpes Preputialis.—Herpes preputialis (often mistaken for lues) has a tendency to recur, invites venereal infection, particularly chancroids and chancres, can usually be controlled by absolute cleanliness, the application of compound stearate of zinc powder and the prevention of mechanical irritation.

Venereal Warts.—Venereal warts frequently develop in the midst of filth and under long foreskins. They are not contagious. They may be single or multiple, large or small. Perfect cleanliness with antiseptic washes may be sufficient treatment to cause their disappearance. Most of them do not respond to such simple measures and must be either destroyed with nitric acid or formalin, cut off close to the surface with a sharp knife or scissors, or cauterized with the high frequency spark. The last method causes the most rapid disappearance and

is the most satisfactory treatment. A redundant prepuce should be removed.

Fibrosis.—Fibrosis of the penis is an abnormal increase of fibrous tissue arranged in masses either in the cavernous or fibrous portions. The mass or masses are found most frequently in the dorsum of the penis, and develop slowly, beginning after middle life. Distortion of the organ may be so marked that coitus is impossible. The fibrosis seldom causes pain. Impotence and melancholia may develop. All forms of treatment have failed and surgery is positively contraindicated.

MALIGNANCY

The most frequent variety of malignant diseases of the penis is epithelioma. The corona or the mucous membrane of the prepuce near its reflection into the sulcus are the usual sites of primary invasion. The early development is slow and it may be treated as an "indolent ulcer" for months before well-defined symptoms of malignancy appear. Malignant disease of the penis must be differentiated from lues. This is best done by blood examination and the use of heroic treatment for lues (Fig. 181).

Fig. 181.—Carcinoma of penis. Began in sulcus at preputial attachment. Inguinal glands enlarged.

When recognized early, and prompt surgical treatment is instituted, the prognosis is only fair. The patient may be relieved for a few years but the probability of recurrence is very great. Surgical treatment to be of value includes complete removal of the inguinal glands together with the entire penis. The pelvic glands which cannot be easily removed may be the nidus for an early recurrence.

True *elephantiasis* of the penis is exceedingly rare in the temperate climates. It is associated with elephantiasis of the scrotum.

TESTICLE AND EPIDIDYMIS

The testicle and epididymis are suspended in the scrotum by the spermatic cord. They are covered by the tunica vaginalis which is

derived from the peritoneum during the descent of the testicle. The tunica vaginalis is normally a closed sac, in which there is a small amount of serum.

The testicle consists of fibrous and glandular tissue. The tunica albuginea is the fibrous covering which gives off numerous supporting trabeculæ that divide the glandular structure into lobules. In each lobule there are several tortuous tubules, containing the spermatogenetic cells from which the spermatozoa are developed. These tubules unite to form straight tubules which carry the secretion into the mediastinum testis from which it is carried to the epididymis by approximately 15 canals. This group of tubules forms the head of the epididymis, which terminates in a single tube known as the body of the epididymis. There are about 20 ft. of this single canal coiled up in the body and tail of the epididymis. Leaving the tail the tube becomes the vas deferens which carries the spermatic secretion to the seminal vesicles and urethra.

Undescended Testicle.—The testicles are developed in the abdominal cavity just below the kidneys where they remain until the fifth fœtal month when they begin to migrate, passing through the inguinal canal and into the scrotum five or six weeks before birth. Their descent may be incomplete and one or both retained within the abdomen, lodged in the inguinal canal or misplaced under the skin of the thigh, abdomen or perineum.

The testicle in the inguinal canal has been mistaken for hernia or bubo and treated accordingly, much to the discomfort of the patient. An undescended testicle, except when retained in the abdominal cavity, is exposed to injury, may, but seldom does, become malignant and often causes in adults mental depression.

The treatment consists in bringing the testicle into its normal scrotal habitat. Some babies at birth apparently have undescended testicles which spontaneously descend within a few weeks. In others, gentle manipulation may aid in moving a testicle from the inguinal canal into the scrotum. If the abnormality persists, the testicle should be exposed and placed in the scrotum. The operation should not be performed before the patient is two years old. The period from 8 to 12 years of age is most favorable for the operation.

There are two obstacles that prevent a ready reduction. One is the short vaginal peritoneal process and the other is the spermatic artery with the anterior group of veins. Bevan's operation overcomes both of these obstacles. The peritoneal process is divided transversely.

The proximal portion is treated the same as the sac in a radical operation for inguinal hernia and that portion attached to the testicle is closed with a purse-string suture forming a tunica vaginalis. It was determined from animal experiments that the nutrition of the testicle will be maintained through the artery and veins of the vas deferens, after the spermatic artery and the anterior group of veins had been severed.

With the peritoneal process and the short vessels severed the testicle can be brought from within the abdominal cavity and placed into the scrotum without tension on the vas deferens and its vessels or detriment to the testicle. A purse-string suture at the external inguinal canal prevents escape of the testicle from the scrotum.

Injuries and Torsion of the Testicle.—The testicle may be traumatized during athletic games, while horseback riding and in many other ways. The pain is severe, and is frequently associated with nausea, syncope and shock.

Swelling soon appears, especially of the epididymis. Pain and marked tenderness continue for several days. Rest in the recumbent posture, support of the testicle and applications of hot wet dressings of lead and opium is the best treatment.

Every testicle that remains enlarged for an unusually long time after an injury should be suspected of undergoing malignant changes. Any injury to the testicle, even though slight, may be the exciting cause and the date of the beginning of malignant change in the testicle, especially during the period from 20 to 45 years of age.

Torsion of the testicle occurs more frequently in the undescended organ and may be produced by muscular effort or injury. Pain, nausea and vomiting follow immediately. Swelling and tenderness soon appear. Very rapid or sudden disappearance of all symptoms except swelling is suggestive that the testicle and that part of the spermatic cord below the twist have become gangrenous. Torsion may be confounded with strangulated hernia. The treatment is surgical and should be applied as early as possible. If gangrene is present, the organ must be removed.

Inflammation of Testicle and Epididymis.—Acute inflammations, other than traumatic of the epididymis and testicle, are due to either hematogenous infection or direct extension along the vas deferens, the latter more frequently.

Epididymitis is a complication in about 15 per cent. of all cases of gonorrhœa in the male. Other microörganisms causing epididymitis and orchitis are the colon bacillus, the streptococcus, the staphylococcus

and the tubercle bacillus. A slight external injury, the introduction of instruments into the urethra, or vigorous massage of the prostate and seminal vesicles may precipitate an attack of epididymitis. It occasionally develops after prostatectomy.

Infections brought to these organs through the blood stream usually attack the testicle first. This occurs occasionally in mumps, but may be due to articular rheumatism, typhoid fever, or other acute infectious diseases. The lesions of the testicle and epididymis being merely metastases due to the bacteria of these diseases.

Symptoms.—The symptoms develop rapidly. Locally there is pain, followed by tenderness and swelling within a few hours. There may be a chill and there is usually some fever. The swelling when confined to the epididymis, as it is in about 80 per cent. of the cases, may be much larger than the testicle. Acute hydrocele frequently develops. The acute symptoms continue from three days to two weeks after which the pain, tenderness, and most of the swelling disappear. A persistent thickening of any part of the epididymis shows that new connective tissue has formed which will prevent the passage of spermatozoa. Some patients who have had double gonorrhœal epididymitis are sterile, but not all of them.

Treatment.—The patient should be put to bed and the scrotum well supported. The best support is a triangle of gauze or soft muslin, while about the worst support for acute epididymitis is the average suspensory. The latter is not comfortable, does not support properly, and constricts the upper part of the scrotum, causing œdema. External applications of hot poultices and counter-irritants, such as guaiacol and iodine are of doubtful curative value, but may be used. Early surgical exposure and multiple puncture of the swollen epididymis gives immediate relief from pain, shortens the duration of the attack, and lessens the liability to sterility.

Tuberculosis of the Testicle and Epididymis.—Tuberculosis of the testicle and epididymis is rarely the primary focus of tuberculosis in an individual. In most cases there are evidences of tuberculosis in some of the other genital or urinary organs.

Symptoms.—Tuberculosis of these organs usually begins in the epididymis as a hard nodule which may be quiescent for a year or more to be aroused by some traumatism or a depletion of the patient's general health. The process may extend until the entire epididymis is involved, producing a mass as large or larger than the testicle (Fig. 182). The pain and tenderness are not particularly discomforting until there is

abscess formation. Hydrocele frequently develops, due to the inflammation having extended to the tunica vaginalis.

The scrotal skin becomes attached to the tuberculous mass, which, having undergone abscess formation, ruptures externally leaving a fistulous tract.

Persistent nodules in an epididymis or an epididymitis without gonorrhea or trauma, suggests tuberculosis. The finding of tubercle bacilli elsewhere in the body is strong supportive evidence.

Treatment.—When recognized early, climatic treatment and out-of-door life are to be recommended with the hope that caseation fo the

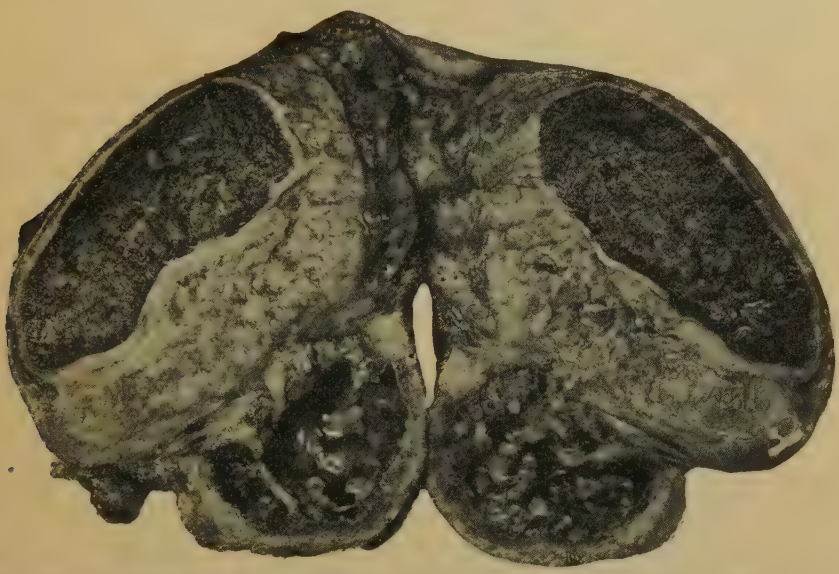

FIG. 182.—Tuberculosis of epididymis and testicle. Abscess cavity in lower part of illustration. (*Author's case.*)

nodules may be prevented. As soon as there is any softening in the small masses they should be removed without delay. If the disease has not invaded the testicle, either a partial or complete epididymectomy is indicated. Involvement of the testicle calls for complete removal with as much of the vas deferens as is possible. Patients with tuberculous nodules in the epididymis, unable to avail themselves of climatic treatment, should have the nodules removed even though there is no evidence of softening. In all doubtful cases, surgical treatment should be reserved until both the blood and therapeutic tests for syphilis have been made.

Syphilis.—Syphilis of the testicle occurs as a tertiary complication. It may appear as early as the sixth month after inoculation, but usually much later. The onset is gradual, painless, and limited to the testicle proper, differing from tuberculosis, which begins in the epididymis. On palpation the enlargement seems smooth, symmetrical and firm, but elastic. A positive diagnosis may depend upon the administration of mercury and the iodides or a Wassermann test carefully made. If luetic, the swelling will soon begin to disappear under this treatment. Treatment with salvarsan (or neosalvarsan), mercury, and the iodides, must be continued until blood examinations together with the absence of clinical symptoms prove the patient cured of his general syphilis.

Spermatocele.—Spermatocele is a cyst, varying in size from a grape to a lemon, and usually contains spermatozoa. Spermatocele is found in the head of the epididymis and is supposed to develop in some fetal structure, such as the hydatid of Morgagni. The development is slow and seldom calls for treatment until it has attained such a size that it causes the patient inconvenience. Aspiration of the cyst contents and the introduction of alcohol or iodine may destroy the sac. If the sac refills, it can easily be removed under local anæsthesia.

Tumors of the Testicle.—Non-malignant tumors of the testicle are exceedingly rare. Cases of fibroma, lipoma, enchondroma, myoma, and osteoma, have been reported. A benign adenoma may become malignant following an injury to the testicle. Teratomata have been found frequently and some pathologists believe that a teratoma is the focus from which every malignancy of the testicle develops.

The most frequent solid tumors of the testicle are malignant either in the form of carcinoma or sarcoma. Sarcoma is more frequent than carcinoma and occurs particularly in patients from 18 to 45 years of age.

Sarcomatous tumors of the testicle grow very rapidly (Fig. 183), often becoming as large as a fœtal head in three or four months. Pain may be severe. The patient fails rapidly. The prognosis is very bad.

Treatment.—Early removal of the tumor including the spermatic cord is the only treatment to be recommended and this does not ensure a favorable prognosis. Recurrence within the abdomen usually follows very soon after the removal of sarcoma of the testicle, death ensuing within a few weeks or months at most. Coley's serum has not proven of much value in sarcoma of the testicle.

Carcinoma.—Carcinoma is rare, may occur at any age, but usually during the period from 35 to 55. Its growth is not so rapid as that of sarcoma, neither does it become as large. The prognosis is bad. Treat-

ment consists of early excision which to be complete must include removal of the spermatic cord and the lymphatic glands.

Hydrocele.—Hydrocele is an abnormal accumulation of fluid in the tunica vaginalis. *Acute* hydrocele is due to an injury or the extension of inflammation from the testicle and epididymis. It may also develop

FIG. 183.—Sarcoma of testicle removed four months after injury.

soon after a radical operation for inguinal hernia. In the acute form the fluid increases rapidly and is attended with some pain.

Chronic hydrocele is either congenital or occurs during adult life. The hydrocele sac (tunica vaginalis) may contain a few ounces or several pints of fluid. The fluid is clear, light straw color, except occasionally

it may contain blood when it is reddish, or it may be milk-like from the presence of lymph, hydrocele chylosa.

The symptoms of chronic hydrocele are those due to its size and weight. The tumor is smooth, elastic, except in those cases with greatly thickened sac wall, is dull on percussion and is translucent. By means of the transmitted light the testicle can be seen at the back of the tumor. If the sac wall is very thick or the fluid milky or bloody the light will not be transmitted. In case of doubt the mass can be aspirated with a hypodermic needle and syringe.

Treatment.—Acute hydrocele should be aspirated every three or four days. If the sac persists in refilling it becomes a chronic hydrocele. A congenital hydrocele may disappear spontaneously during the first few months after birth. Tapping or aspirating a chronic hydrocele gives temporary relief, but the sac refills within a few weeks. Injection of the sac, after it has been emptied, with 10 drops of pure carbolic acid, 20 drops of tincture of iodine, or a dram of pure alcohol will be successful in some cases. The inflammatory reaction is such that the patient should remain quiet with the scrotum well supported for several days. It is wise to warn the patient that very great swelling may follow the injection but that it will subside in a few days. The injection treatment is not suitable to cases with (1) thick wall, (2) complicating organic disease of the epididymis or testicle, or (3) when hernia is present.

Excision or eversion of the hydrocele sac—the tunica vaginalis—gives the most satisfactory results. There can be no recurrence. In each the tunica is exposed and separated from the scrotum by blunt dissection. The sac is opened. In excision the sac is cut away close to the testicle and cord. The testicle is replaced in the scrotum, the incision closed with a small drainage which is left in for 24 hours.

In eversion the testicle is brought through the incision and the sac is turned inside out, the cut edges being sutured behind the testicle. If the sac is very large it should be trimmed down until there is only enough to meet behind the testicle. The operation is finished in the same manner as after excision of the sac.

Hydrocele may be an open sac communicating with the peritoneal cavity and separated from the tunica vaginalis. The fluid contents of such a sac disappear into the abdomen when the patient is in the recumbent posture. This is a congenital type and predisposes to hernia.

Hydrocele of the spermatic cord is a congenital anomaly in which there remains a portion of the peritoneal fold that has been separated

from both the peritoneal cavity and the tunica vaginalis. This closed serous sac is usually located in the inguinal canal and has been mistaken for hernia, bubo, and undescended or supernumerary testicle. It is a fixed enlargement differing from hernia and there is no inflammation as in a glandular infection. The presence of the testicle in the scrotum rules out undescended testicle and a supernumerary testicle has never been authentically recorded.

Hematocele.—Hematocele is a tumor due to hemorrhage into the scrotal tissues or tunica vaginalis. Trauma of the scrotal sac and contents, straining at stool, violent coughing or sudden violent physical exertion are causes of hematocele.

The tumor develops quickly, is smooth, symmetrical, soft, but later, as the clot becomes organized, it may be very hard. The clot is usually absorbed within a few weeks. In some cases absorption is not complete and a hard mass remains which may be mistaken for a neoplasm. Occasionally the clot becomes infected, forming an abscess.

Treatment.—The treatment in recent cases is palliative and expectant. Rest in bed, support of the scrotum and applications of aluminum acetate solution for one week produce satisfactory results in most cases. No attempt to remove the clot surgically should be made in recent cases on account of the great danger of infection. Organized clots remaining after many weeks can be safely removed.

Varicocele.—Varicocele is a dilatation of the spermatic veins, found frequently in young adults, affecting the left side most frequently. The same condition is occasionally seen on the right side. A marked varicocele which appears in middle or late life is suggestive of an abdominal tumor. This is especially true of right-sided varicocele.

Oft-repeated, ungratified sexual stimulation causes prolonged congestion of the vessels and is a causative factor in producing varicocele in the young. The left side is involved more frequently than the right because the left side of the scrotum and the left spermatic vein are longer than the right and the left spermatic vein empties into the renal vein at a right angle while the right spermatic vein empties into the vena cava at an acute angle. Chronic constipation is also a predisposing cause.

In varicocele the veins in the scrotum can be felt as a bundle of small soft tubes. Greatly dilated veins are seen as coils under the skin.

Symptoms.—The symptoms of varicocele are not always in direct ratio to the size of the dilated veins. Ofttimes a slight varicocele produces more marked symptoms than one with enormously dilated veins.

Acute varicocele comes on suddenly, giving rise to local discomfort and pain or dull ache with sense of weight and heaviness.

Chronic varicocele may cause slight pain radiating to lumbar regions, groin or thigh. Neurasthenic symptoms are very common. The patient complains of feeling nervous, tires easily, says he cannot concentrate his mind on the duties at hand, feels depressed, has headaches and fears impotence.

Treatment.—The treatment is either palliative or surgical. Varicocele of small size with only slight symptoms can be relieved by the avoidance of undue sexual excitement, the wearing of a proper suspensory and regulation of the bowels. Systematic physical exercise, out of doors if possible, followed by shower baths is helpful.

If the patient suffers much distress and the neurasthenic symptoms pronounced, surgical treatment is indicated, except there be present tuberculosis of the epididymis.

The operation consists of exposing the bundle of veins, ligating them at two places about 1½ or 2 in. apart and cutting that portion of the veins between the ligatures. Care must be taken not to include in the ligatures the spermatic artery and the vas with its accompanying artery. If both these arteries are severed the testicle will become gangrenous and must be removed. Exposure of the veins through a skin incision made transversely just below the external abdominal ring is less liable to infection than when the scrotum is incised. A few days rest in bed with the scrotum well supported and a proper fitting suspensory worn afterward is the only after-treatment necessary. Resection of the lower portion of the scrotum for an excessive pendulous condition is most satisfactory. Clamps are applied just above the level of the line of the incision and the redundant portion of the scrotum removed either with a knife or scissors. Before removing the clamps, through-and-through sutures are applied. The clamps are removed and the cut surfaces of the scrotal wall are apposed with interrupted sutures.

SEMINAL VESICLES

Anatomy.—The seminal vesicles are located between the bladder and rectum external to the ampullæ of the vasa deferentia and above or posterior to the prostate gland (Figs. 184 and 185).

On account of their close proximity to the bladder, rectum, and prostate, many symptoms due to pathological conditions in the vesicles are referred to these adjacent structures.

The normal vesicle is made up of a number of saccules (Fig. 186) communicating with a common tubule which joins the vas deferens at the posterior border of the prostate to form the ejaculatory duct. This duct communicating as it does with the posterior urethra offers a direct line of transportation for organisms from the urethra to the vesicles (Fig. 187).

The structure of the vesicle wall is a fibrous sheath externally, mucous membrane internally and between these two a well-defined muscular layer.

The seminal vesicles as a part of the sexual apparatus, enter into the activity of every sexual excitement either gratified or ungratified.

FIG. 184.—Posterior view of normal vas deferens, seminal vesicles, and prostate.

With each penile erection there is a corresponding engorgement of the blood-vessels of the seminal vesicles and surrounding tissues. With each ejaculation there is added to the increased blood supply and tur-

FIG. 185.

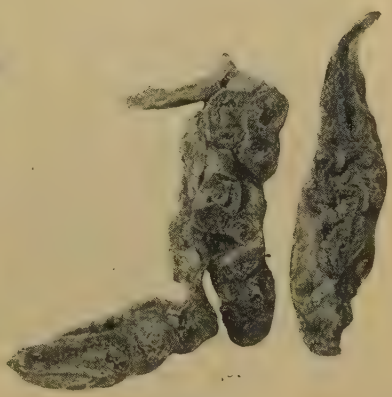

FIG. 186.

FIG. 185.—Same as Fig. 7, with posterior lobe of prostate divided and turned out showing the ejaculatory ducts in the inch line, and the close relation of the vesicles to the prostate.
FIG. 186.—Normal vesicles. 1. Cut antero-posteriorly. 2. Cut from side to side.

gescence due to sexual stimulation, the mechanical and physical effort necessary to empty the vesicles.

The seminal vesicles differ in no way from other structures of the

body that render them immune to damage when abused and overworked. It is for this reason that sexual indulgence very early in life is harmful. Oft repeated demands upon these structures before they are mature, will produce an abnormal and premature development. This accounts for the almost insatiable sexual desire in some young men, 18 to 25 years of age. In nearly every instance these individuals began

FIG. 187.—Radiograph of normal seminal vesicle and vas deferens injected with 10 per cent. collargolum.

sexual practice either normal or abnormal about 14 years of age. Soon after 30 or 50 years of age these same individuals begin to notice, not only a loss of sexual desire, but also diminished sexual strength. They complain of premature ejaculations followed almost immediately by penile flaccidity. Some suffer from complete impotence and all of its accompanying mental anguish. Upon rectal palpation of the vesicles

in such cases, and there may or may not have been a history of gonorrhea, one finds that the vesicles are larger than normal that they are not freely movable and that they are tender to the touch.

Urethral instrumentation and applications of strong solutions of silver to the posterior urethra may aggravate the vesicle conditions and increase the symptoms.

Further examination of these cases by dissection and visual inspection shows that the vesicles are bound in adhesions, ofttimes so thick and abundant that the upper border of the prostate is buried so that it cannot be readily felt. The walls of the vesicles are thickened and have lost much of their resilience. It is with difficulty that they can be loosened from their attachment to the bladder wall. The interior of such vesicles present numerous granulations which render the vesicles functionless.

FIG. 188.—Section of vas deferens and seminal vesicle showing multiple pus cavities in upper part of the vesicle.

Infections of the vesicles are of a large variety and occur frequently. Among the infections are colon bacillus, micrococcus catarrhalis, tubercle bacillus, staphylococcus, streptococcus, and the gonococcus. The seminal vesicles are exposed to infection from the blood-stream, from adjacent structures, directly through the ejaculatory duct, and vas deferens. Their anatomical construction favors the harboring and growth of infectious organisms. The left vesicle like the left epididymis is more frequently the first to be infected, but seldom is the infection limited to one side. The infection first attacks the mucous membrane, producing an inflammation which rapidly extends to the muscular and fibrous structures of the vesicle wall. Pus sacs are frequently formed (Fig. 188).

Symptoms.—Nervous and mental symptoms due to chronic seminal vesiculitis are often treated for simple neurasthenia, lumbago, nervous indigestion or neuralgia. Many suffer mental depression and are melancholic.

The urinary symptoms may be those of chronic cystitis. Cystoscopic examination shows the bladder floor elevated and œdematous. Relapsing urethral discharges without a recent exposure to infection is often due to a vesiculitis.

During the acute stages of seminal vesiculitis the sexual function is

over-stimulated and the patient suffers from painful priapism, particularly at night. Nocturnal emissions are frequent and the discharge is often blood stained. Sexual activities are indulged in with little or no satisfaction. The patient complains of pain referred to rectum or perineum, may have dysuria or retention, together with the usual symptoms of infection, such as chill, fever and malaise. The vesicle feels to the examining finger boggy, swollen, hot, and the patient complains of severe pain from the slightest pressure. The border line of the prostate is obscured by the perivesicular œdema and swelling. The acute inflammation may subside leaving the parts practically normal, but this seldom occurs. Perivesicular abscess occasionally forms and ruptures or is opened into the rectum.

Even though the symptoms of acute inflammation and active infection disappear there remains enough latent infection to subsequently start trouble on slight provocation, even years later.

Chronic vesiculitis produces a toxine which is responsible for many and varied symptoms. Every adult male suffering from neurasthenia should be examined as to the condition of his seminal vesicles. A history of gonorrhœa is not essential to vesicle pathology. Many sexual and urinary disturbances are due to chronic vesiculitis. Practically all of the symptoms of cystitis are at times produced by seminal vesiculitis. Recurrent urethritis without exposure to reinfection may appear at intervals for years in spite of persistent urethral treatment, when there is a chronic infection and inflammation of the seminal vesicles.

Chronic arthritis very frequently has its source in the seminal vesicles. This complication may develop early in the history of the patient's gonorrhœal infection, but it more frequently appears after one or two years and as late as six or seven years. Even though the gonorrhœal arthritis is of long standing, there are seldom any marked changes in the articular surfaces of the bones forming the joint or joints involved. This, of course is not true of the very acute gonorrhœal infections of joints that occur during the acute stages of gonorrhœal urethritis, as these cases very frequently terminate in an ankylosis.

Long-continued infections and inflammations of the vesicles tend to destroy the normal structures, leaving a large multilocular sac devoid of the normal mucous membrane. Many specimens examined showed that the ampullæ of the vas were also often the seat of similar infection and destruction. The communication from the vesicle to the ejaculatory duct, or the duct itself, may become occluded either temporarily or permanently. Knowing as we now do that chronic inflammation of

the seminal vesicles is rather frequent and that it destroys their function, we may correctly conclude that this accounts for many sterile men who have never had epididymitis.

Treatment.—Acute vesiculitis is best treated by rest in bed, rectal irrigations of hot water, and anodynes for the pain. Massage is contraindicated.

Chronic vesiculitis should be treated with massage every five to seven days. After each massage a good-sized metal sound is to be introduced followed by a urethral irrigation (Janet), with a mild antiseptic solution. A large majority of the cases will be relieved if this treatment is properly applied over a period varying from a few weeks to a few months. When purulent material persists in the vesicles they can be drained and irrigated through an incision in the vas deferens. Through a tube placed into the lumen of the vas in the upper part of the scrotum under local anæsthesia is introduced a solution of some silver salt which fills the vesicle and acts as a bactericide. The tube can be left in place for several days, during which time two or three injections may be made. This may be sufficient for a complete cure.

Cases of long standing, where the symptoms are not relieved by the simpler methods, should be treated surgically. The vesicles are exposed, incised, packed with gauze and drained for 10 to 14 days. Most satisfactory results follow the radical treatment of old cases, where the vesicles are bound down in adhesions, and are the foci of infection and toxæmia. The mental and nervous symptoms disappear, sexual strength improves, normal urinary conditions are restored and the arthritis cases are relieved.

Tuberculosis of the vesicles is seldom if ever primary. Such vesicles are hard and nodular to the touch. Tubercle bacilli can with diligent search be demonstrated in the expressed vesicle contents. The treatment is that of general tuberculosis. Surgery is contraindicated.

Calculi are found occasionally in the vesicles usually at the time of the vesiculotomy.

The ability to recognize the various pathological conditions in the vesicles, together with the symptoms, comes from long experience with a large number of cases.

Functional Disorders and Sexual Neuroses.—Disturbances of the physiological function of the sexual apparatus are frequent. They are usually of psychic origin and are magnified by the influence of the patient's mental attitude. In the functional disorders there is seldom a

local organic lesion, and if one be present the symptoms are out of all proportion to the importance or gravity of the lesion.

Patients suffering from functional sexual disorders and neuroses are often considered lightly and indifferently by the physician, which in itself is a great factor in driving them to the charlatan and quack. They are real sufferers and deserve the most careful consideration. In fact, they are often much more miserable and are in greater need of special care than many who have definite well-marked organic lesions. Included in these disorders are masturbation, nocturnal emissions and impotence.

Masturbation and its effect on the general health have been exaggerated, and many young men are sexual neurasthenics because they have been led to believe that their early practices—or better mal-practices—have so undermined the entire physical constitution and so disordered the sexual organs that they can never again become normal. This is positively an erroneous general conclusion. It cannot be disputed that excessive masturbation practised over a long period of time is exceedingly harmful, yet in such cases it is frequently a symptom of some mental disturbance. While masturbation is common among boys, it is usually discontinued when the boy becomes endowed with correct knowledge of morals and of things sexually. The mere fact of this early error does not condemn the individual morally or sexually. Most of these patients will blushingly confess their early practices, and ask if anything can be done to overcome the damage done at the time. They suffer from ideas of "lost manhood," atrophied sexual organs, imaginary varicocele, sexual impotence and divers and sundry other imaginary conditions. These ideas are often due to books and pamphlets published by quacks and charlatans on the dangers of masturbation. Often the beginning of this sexual neurasthenia may be traced to the time when the patient read some such literature.

Treatment.—A thorough physical examination, careful instructions as to the proper food, exercise and hygiene, a positive assurance that his former indiscretions have not caused irremediable damage together with the cooperation of the patient will produce satisfactory results in most instances.

Anæmic patients should be treated for the anæmia. Licentious literature, immoral theatricals, alcohol and tobacco should be avoided by one who desires to discontinue the practice of masturbation, or who is suffering from sexual neurasthenia.

Nocturnal Emissions.—Nocturnal emissions are usually physiological and their frequency within physiological limits will vary with different individuals. Unless they are abnormally frequent, in which case there is a cause, such as chronic urethritis, prostatitis or seminal vesiculitis, the patient's mind can be put at ease concerning the "terrible drain on his constitution from these night losses." It must be determined that there is no organic trouble present, and then the patient must be warned against all kinds of unnatural sexual excitement.

Impotence.—Impotence is an inability on the part of the male to properly perform the sexual function. Either there is no erection or there is premature ejaculation of the seminal fluid or else there is no seminal discharge.

Impotence is either physical or psychical. In the lumbar region of the spinal cord is located a group of ganglia which controls erections. This center of erections is stimulated or inhibited by mental influence. Injury or disease of the spinal cord often produce persistent and even painful erections. Erections are also caused by peripheral irritations from an overfilled bladder, acute inflammation in the prostate, vesicles or verumontanum, and from prostatic hypertrophy. Many old men with prostatic enlargement have frequent erections and strong sexual desires. These same causes of priapism may also, if existing for a long time, be responsible for the loss of erectile power.

Physical impotence is either congenital or acquired. Among the congenital causes are epispadias, hypospadias, and small size of the penis. Syphilitic destruction of the penis, malignancy, fibrosis in the cavernous bodies, injuries, elephantiasis, large scrotal hernia, scrotal tumors and pendulous abdomen may make it impossible to perform coitus. The treatment consists in removing the cause or correcting the deformity when possible.

Psychical impotence is often a sequel of sexual excesses or abnormal sexual practices particularly in individuals of a neurasthenic temperament. Business reverses and mental worry from whatever cause are contributing factors. With some, impotence is a relative condition as they can cohabit with a special type of woman under certain surroundings but failure attends all other efforts.

Treatment.—The success of the treatment of psychical impotence depends upon the removal of the predisposing causes and the restoration of an equilibrium in the nervous and mental systems. The most important factor towards bringing about this improvement is a physician who is in absolute command of the situation and one in whom the

patient has implicit confidence. The patient must be instructed that no sexual effort is to be made, that he should abstain from alcoholic and narcotic stimulants, eat regularly of wholesome food, indulge in systematic physical exercise in the open air if possible, and sleep at least eight hours each night in a well-ventilated room, or better on a sleeping porch.

If in addition to the psychic condition there is present a posterior urethritis, colliculitis, prostatitis, or vesiculitis, these must be treated according to the pathological conditions found after careful examination.

It must be borne in mind that each case is a case unto itself, which in some instances taxes beyond measure the ingenuity of the physician, before he obtains complete mastery of the situation.

SECTION XVI

AFFECTIONS OF THE SPINAL COLUMN

By

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Antenatal or developmental lesions of the vertebral column, that persist during extra-uterine life, are comparatively few in number. Certain of them affect the skeleton as a whole, achondroplasia, for example; others are confined to the spine and affect a limited portion of it. These include anomalies in the number of vertebræ, either in the direction of excess or diminution, and in the formation of individual vertebræ. The most familiar anomaly is a defective union of the laminæ resulting in the various forms of *spina bifida*. Defective formation of the bodies of the vertebræ, causing *congenital curvature of the spine*, has become better known since the wider adoption of radiographic examination.

Spina Bifida.—Spina bifida is a congenital defect in certain of the vertebral arches which permits of a protrusion of the contents of the spinal canal. It is due to an arrest of development, whereby the closure of the primary medullary groove, and the ingrowth of the mesoblast to form the spines and laminæ fail to take place. The defect usually extends over several vertebræ. The condition is most common in the lumbo-sacral region, next in the cervical, and is least common in the dorsal segment. It is sometimes associated with other developmental anomalies, notably with hydrocephalus.

It is usual to describe four varieties according to the character of the protrusion.

1. *Spinal meningocele* in which only the membranes and the cerebrospinal fluid are protruded. This is the rarest variety and is almost confined to the cervical region.

2. *Meningomyelocele* which is the most important from the clinical point of view; in it the cord and spinal nerves are protruded, the nerves being spread out over the inner aspect of the sac. Instead of forming a complete tube, the cord remains in the primitive condition of a groove

or plate adherent to the posterior wall of the sac; from its sides are given off the nerve roots which then enter the vertebral canal.

3. *Syringomyelocele.* In this there is a dilatation of the central canal in the protruded portion of the cord, which has now reached the condition of a complete tube. In these three forms the protrusion may be covered by healthy skin or by a thin translucent membrane.

4. *Myelocele* or rachischisis posterior, in which the skin is defective and the cord lies exposed in a shallow groove.

In the saccular forms of spina bifida, the cavity is lined by the arachnoid only, as Recklinghausen demonstrated that the dura terminates at the circumference of the bony opening and is not found over the tumor itself. In some cases of meningocele the connection which originally existed between the sac and the vertebral canal is lost and a simple cyst remains.

Clinical Features.—The presence in or near the middle line of the back of a swelling, that has existed since birth, and which contains fluid and increases in size and tenseness when the child cries, renders the diagnosis comparatively easy.

The presence of an umbilicated depression or furrow in the center of the tumor corresponds to the site of attachment of the spinal cord.

The swelling may be reduced in size by making pressure over it, and in young children this may cause a bulging and increase of pressure in the anterior fontanelle. In a considerable proportion of cases there are paralytic symptoms referable to the lower extremities, sometimes motor, sometimes sensory. The paralysis may also affect the sphincters of the bladder and rectum, with incontinence of urine and fæces and a patulous condition of the anus through which a prolapse of the mucous membrane of the rectum may take place.

Spina bifida occulta is that condition in which there is no protrusion of the contents of the spinal canal, although the vertebral arches are deficient. The skin over the defect in the bone is often puckered and adherent, and is covered with coarse hair and a mass of fat, which in the lumbo-sacral region may suggest a caudal appendage or tail. Like other forms of spina bifida, it may be associated with paralytic symptoms in the lower extremities and in the sphincters of the bladder and rectum and these are ascribed to the traction of a tough strand of connective tissue, fat and muscle, stretching from the skin to the lower end of the spinal cord.

The diagnosis of obscure forms of spina bifida, and particularly of the occult variety can be established with certainty by means of radiograms.

Occurring as it does in children and with greater frequency in the cervical and lumbo-sacral segments, good pictures are obtained and the defect in the laminæ is easily recognised.

The prognosis of spina bifida, although favorable in the pure meningoceles, is always grave, the majority succumbing in the early years of life to leakage of cerebro-spinal fluid, to septic meningitis, or later to hydrocephalus.

Treatment.—The tumor is protected from pressure and from infection until the vitality of the child is established. In a few selected cases the tumor may be excised. The buttocks are raised and the head is lowered to retard and diminish the loss of cerebro-spinal fluid. The tumor is outlined by two elliptical incisions, the neck of the protrusion is isolated and divided, and the proximal end is hermetically closed by suture. A proportion of the successful cases afterwards succumb to hydrocephalus.

The hope of *improvement in the motor symptoms* after operation depends on the site of the spina bifida; above the twelfth dorsal vertebra, there is no prospect of improvement; below this level, inasmuch as it is the tip of the conus or the cauda equina that is involved, there may be regeneration of nerve fibers and return of power in the lower extremities, and control of the sphincters may be regained. Murphy has practised resection of cicatricial or atrophied portions of the cauda, with end-to-end suture.

Congenital Tumors of the Sacrococcygeal Region.—These form a clinical group embracing sacral spina bifida, fœtal inclusions and mixed tumors, usually cystic in character. The tumors are of special interest as some of them take origin from the remains of the neurenteric canal or postanal gut which passes between the cord and the intestine and is lined by epithelium resembling that of the intestine. Ciliated epithelium, similar to that lining the central canal of the spinal cord, may also be found lining the cystic spaces of the tumor. Various types of tissue contribute to the solid parts of the tumor; some of them, embryonic in character, are suggestive of sarcoma. Useful information is usually furnished by radiograms.

These tumors are more common in female children and like all cystic tumors are capable of increasing in size with great rapidity. The sessile variety presses the anus forward and the sacrum and coccyx backward and projects also in the ischiorectal region. The pedunculated variety may come to hang as low as the knees, and the skin covering the tumor is liable to rapid ulceration.

Those tumors which develop in front of the sacrum are best in-

vestigated from the rectum; they interfere with the functions of the bladder and bowel.

FIG. 189.—Skiagram of infant aet. 1¾ years, showing congenital scoliosis from defective development of vertebræ, specially affecting the last dorsal and upper three lumbar. There is also fusion of the seventh, eighth and ninth ribs on the left side.

The removal of these tumors by operation should not be lightly undertaken. It is important to remember that partial removal

has sometimes been followed by disappearance of the portion left behind.

Paracoccygeal or Pilonidal Sinuses.—All degrees are met with, from a mere dimple in the skin near the tip of the sacrum to an invagination

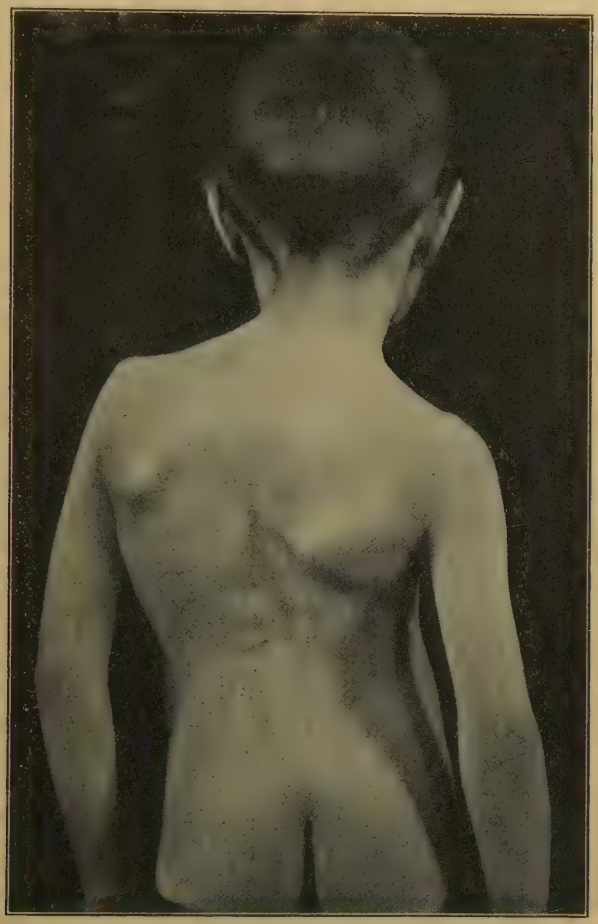

FIG. 190.—Congenital scoliosis in a boy aet. seven, due to the interposition of an extra half-vertebra between the bodies of the eighth and ninth dorsal vertebræ on the left side. The photo shows the primary dorsal curve, and the secondary cervical one and the difference in the level of the scapulæ. (*Dr. David M. Greig's case.*)

or tunnel, lined by skin. When the sebaceous secretion is pent up, and infection is superadded, a suppurating sinus results which has little or no tendency to heal. We have seen this condition mostly in young women; the mistake is commonly made of regarding it as tuberculous and as arising in disease of the bone.

The best treatment is excision, the resulting wound being treated by the open method.

Congenital curvatures or deviations of the spinal column may depend upon an excess in the number of vertebræ, upon the absence of a part or of an entire vertebra, or upon fusion of vertebræ, and any one of these may be complicated by abnormalities in the ribs. Figure 189 illustrates a condition observed by John Fraser and J. W. L. Spence. The seventh and eighth dorsal vertebræ are represented on the right side by two half vertebræ, each of which tends to be wedge-shaped, and on the left side by the fusion of the two vertebræ into a single wedge-shaped bone. The twelfth dorsal vertebra is divided into two halves by a mesial division. The first three lumbar vertebræ show a deformity similar to that in the seventh and eighth dorsal. On the left side there are 13 ribs and the seventh, eighth, and ninth are fused about 1 in. from the side of the vertebral column into a single broad rib. Such cases illustrate the necessity of radiographing the spine in all conditions that are not easily explained.

David M. Greig records a case in which a congenital scoliosis (Fig. 190) resulted from the interposition of an extra-half vertebra between the bodies of the eighth and ninth dorsal vertebræ on the left side. On the same side, also, there was a thirteenth rib.

D. C. L. Fitzwilliams also records a case of congenital scoliosis. The child, a female aged 16 months, showed a definite angling of the spine, convexity to the right, at the dorsolumbar junction; there were compensatory curves above and below. The curvature was due to the presence of a wedge-shaped vertebra with rudimentary processes. The diagnosis from rickets was made on the grounds that in this condition the curve is rounded, it involves the whole column, it is usually associated with kyphosis and it disappears on suspension of the child by the lower extremities.

Pseudo-fracture of Transverse Process.—Dr. Rhys has called attention to a condition observed in radiograms of the adult lumbar spine in which there is a gap between the tip of the transverse process and its base, which is liable to be regarded as a fracture. There is an absence of history of injury in almost all the recorded cases and the first lumbar is the most frequently affected, sometimes on both sides. He ascribes the lesion to incomplete ossification, it being analogous, therefore, to a separate acromion process; he also suggests that the separate transverse process may represent an attempt at the formation of a supplementary rib, a view supported by Reginald Morton.

Traumatic Affections.—The traumatic affections associated with injury to the cord or nerve roots are dealt with in the chapter that follows; we are here concerned with those in which the nerve structures have escaped injury (Fig. 191). We shall not give a systematic de-

FIG. 191.—Compression-fracture at dorso-lumbar junction showing projection of spinous process.

scription of the sprains, fractures, and dislocations that come under this head, as this would be out of place.

Gross injuries of the vertebræ, such as fracture or dislocation, may occur without damage to the cord or nerve roots, and while there is no

immediate danger to life, there may result varying degrees of disability. This is especially true of dislocations of the cervical vertebræ; if these are not recognized and reduced, repair and consolidation are deficient, and in addition to deformity and stiffness, the patient feels a want of confidence and may have to rely upon an external support. The X-rays have proved a valuable addition to the previously existing methods of diagnosis, and fractures and dislocations are now recognized that were formerly overlooked, the patient being treated for rheumatism, neuritis and the like, or being regarded as a neurasthenic or a malingerer. In old, unreduced dislocations in the cervical region, de Quervain has obtained fixation of the affected vertebræ by a splint of bone taken from the spine of the left scapula, giving the patient confidence, and enabling him to move the adjacent joints more freely.

Eight cases of isolated fracture of the lumbar transverse processes have been reported due to forcible lateral flexion from falling rock, severe strain or a direct blow. Three were diagnosed by the X-ray after several months of symptoms due to non-union. The symptoms are slight swelling, localized pain on pressure or on movement, especially toward the injured side, relieved by lying down, and muscular rigidity. The fracture itself is of minor importance, but its recognition as a cause of the above symptoms, which may become chronic if not properly diagnosed and treated, is of great importance. The history of the injury and especially the X-ray, establishes the diagnosis. Many such cases have doubtless been overlooked and regarded as merely sprains (George Woolsey).

Radiography in the Diagnosis of Fractures and Dislocations.—Several exposures are usually necessary, and the plates must be carefully analyzed and compared with plates of the normal spine, as mistakes are liable to arise from overlapping of the contours of the bodies and arches.

In the *upper cervical segment* the best pictures are obtained by ventro-dorsal exposures through the widely opened mouth, and these should be controlled by lateral exposures.

For the *lower cervical segment*, the patient lies on his side, the head is fixed with sand bags, the shoulders are depressed, and the breathing must be shallow or arrested. Even slight torsion of the cervical spine causes the transverse processes on one side to project forward, and this may suggest fracture.

In the *dorsal segment*, the pictures are made from before backward in the sagittal plane, or obliquely from right anterior to left posterior,

the latter method eliminating the shadow of the heart. The dense viscera in the mediastinum, and in the lower part, the diaphragm and liver, obscure the contour and structure of the vertebræ.

The *lumbar segment* is taken ventro-dorsally; the bowels having been emptied, the patient lies on his back, the thighs are flexed to relax the abdominal wall and to undo the normal curve of the spine. The upper and lower edge of each body may throw a double line of shadow, one line representing the anterior half, and the other the posterior half of the body.

Traumatic Spondylitis.—This condition, first described by Kümmel is characterized by pain and disability and by curvature of the spine

FIG. 192.—Compression fracture at dorso-lumbar junction followed by traumatic spondylitis.

following upon injury. It is believed to originate in a compression fracture at or near the dorso-lumbar junction which has not been recognized, and is probably due to the callus thrown out for the repair of the fracture being subjected to strain and pressure too early, or to a progressive softening of the injured vertebra and of the bodies of those adjacent to it. This leads to an alteration in the shape of the affected bones. The usual history is that some considerable time after the patient has resumed work he suffers from pain in the back, and radiating pains round the body and down the legs. He becomes more and more unfit for work, and a marked projection appears in the back and may come to involve several vertebræ. While the condition is progressive,

the prominent vertebræ are painful and tender. In course of time the softening process is arrested, and the affected bones become fused, so that the area of the spine involved becomes rigid and permanent deformity results (Fig. 192). The diagnosis and course of the affection should be controlled by radiograms. So long as the condition is progressive the patient should be kept in the recumbent position, and when he gets up, the spine should be supported by a jacket.

Pyogenic Infections.—Pyogenic infections through the blood stream are much less likely to involve the bones and joints of the vertebral column than those of the extremities. The organisms concerned are the ordinary pyogenic ones; those of acute rheumatism and of gonorrhea have not yet been observed in the spine. In pyæmia the spine is very rarely affected, although pyæmia may originate in a suppuration having its origin in the vertebræ.

Staphylococcal osteomyelitis and arthritis affect adults as well as children, and may or may not supervene on a recognizable source of infection, such as a boil or a whitlow. In typical cases, several vertebræ are affected, usually in the lumbar region; one or more bodies may undergo necrosis, *en masse*, or in small pieces with destruction of the discs, or the infection is limited to the arches and processes. When pus is formed it makes its way to the surface along the usual paths or it may erupt into the pleural cavity.

The clinical features are those of acute pyogenic infection together with pain in the back and legs. Rigidity of the spine although usually present, is not easily demonstrated. The patient lies on his back, and if asked to move, does so with great deliberation. One or more vertebræ are usually found to be specially sensitive. The diagnosis is completed when there is the rapid development of an angular projection or the formation of an abscess in the posterior triangle of the neck, chest-wall, loin or iliac fossa. In the dorsal region, the suppurative lesion may show as an empyema, and in the lumbo-sacral segment as a pelvic cellulitis spreading down into the ischiorectal fossa. Involvement of the contents of the spinal canal is not uncommon so that search should be made for signs pointing to this. Owing to the acute nature of the disease, skiagrams are rarely of any value.

The mortality is very high (60 to 70 per cent.); the prognosis is more favorable when the arches are alone involved. Sundermann records a case in which recovery took place after rupture of an abscess into a bronchus and the discharge by coughing of several sequestra.

The *treatment* is early exploration by operation; emptying and drain-

ing the abscess is often all that is possible, but, if the diseased bone is accessible, it should be removed, as healing is thereby promoted and the risk of infection of distant parts diminished.

Precautions, such as weight extension, may be required to prevent deformity. Should recovery take place there is usually complete restoration of function.

Typhoid infection of the vertebræ, which occurs during convalescence from enteric fever, may present suppurative features, similar to the staphylococcal infections only less acute, or it may run a dry and comparatively latent course. The dry form, better known as "*typhoid spine*," is associated with pain in the back and legs, and stiffness of the vertebral column. From its slow onset and progress it is liable to be regarded as Pott's disease; the X-rays prove helpful in the differential diagnosis as in tuberculous disease they usually reveal decided changes in the bones. If pus forms it will cause a swelling in the loin or iliac fossa as the lumbar vertebræ are those most commonly affected. It is rare for the spinal cord or membranes to be involved. The prognosis is good, recovery taking place in from 6 to 12 months. Operative interference is rarely called for, but measures to prevent deformity may be required.

Vertebral Tuberculosis.—Tuberculous spondylitis is so common that it is by far the most important affection of the spine in general practice. In its typical form, as met with in children in whom the diseased bodies of the vertebræ rapidly give way causing the early appearance of an angular projection (Fig 193), the diagnosis is usually a straightforward one. It may be difficult, however, if the patient is brought to us before there is any deformity or before abscess formation, as is more frequently the case in adults.

In addition to the methods of diagnosis upon which we formerly depended, the X-rays now play an essential part, not only in the *diagnosis of Pott's disease* but in determining the exact nature of the lesion as well as its extent, and in many cases also they afford information as to the progress of the disease, whether toward cure or extension. As in other affections of the vertebræ, great caution is required in the interpretation of the radiograms; it is desirable that these should be compared with radiograms of the normal spine taken under similar conditions and as nearly as possible obtained from subjects of the same age. The most obvious alterations are those affecting the axis of the spine; lateral deviations that would escape recognition by ordinary clinical examination are easily demonstrated, and draw attention to the condition of the verte-

bræ at the summit of the curve (Fig. 194). In the cervical, lumbar and sacral segments, it is usually possible to identify the pathological changes in detail; in the dorsal segment and dorsolumbar junction it is difficult to see details and one has to rely upon such evidence as blur-

FIG. 193.—Tuberculous disease at dorso-lumbar junction showing almost complete destruction of the body of a vertebræ. (*Museum Royal College of Surgeons, Edinburgh.*)

ring of the outlines of the vertebræ, changes in their size, in the intervals between the bodies corresponding to the intervening fibrocartilages, and in the intervals between the ribs. The bodies and the ribs become crowded together in progressive lesions. The disappearance of normal structures in the diseased area may assist in the interpretation of

appearances; the articular processes, for example, when traced from above and below are often observed to disappear.

FIG. 194.—Skiagram of specimen of tuberculous disease at dorso-lumbar junction. (*Dr. Hope Fowler.*)

A prevertebral abscess often yields a rounded, or more often elliptical (the long axis of the ellipse being vertical) shadow, obscuring the

outlines of the vertebræ behind it (Fig. 195). Radiograms taken at intervals of a month or so may show alterations in the size of the prevertebral abscess, extension of the tuberculous process to adjacent vertebræ or the formation of new bone in and around the affected segment of the spine which may indicate the cure of the disease. The interpretation of radiograms is especially difficult in cases which have

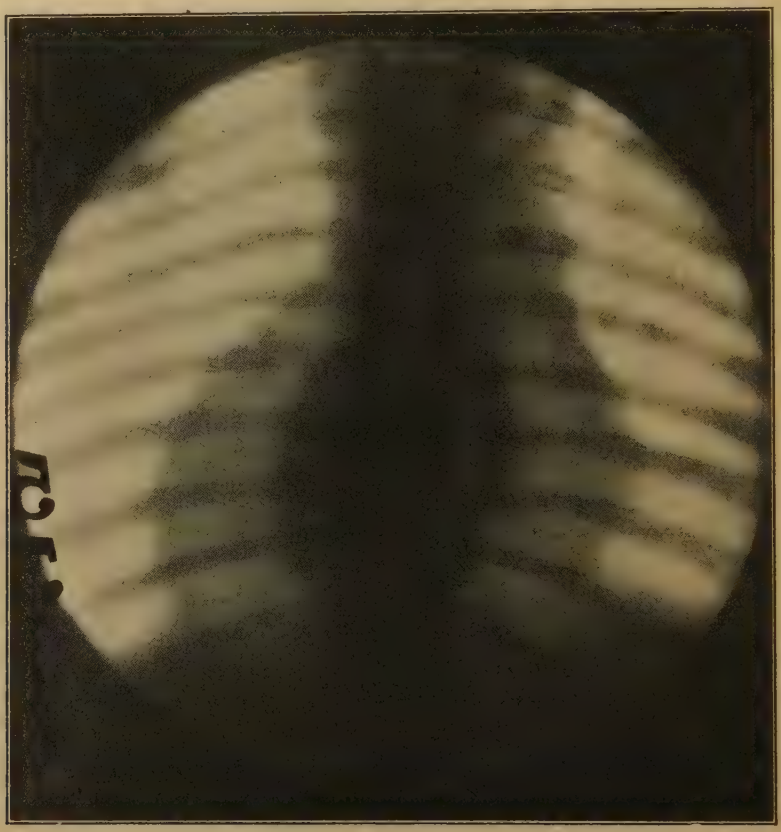

FIG. 195.—Skiagram of dorsal spine of child showing a circumscribed abscess in relation to tuberculous disease of eighth and ninth dorsal vertebræ. (*Dr. John W. L. Spence.*)

relapsed, it may be years after apparent cure, as the shadow of the bone formed in the process of repair obscures the details in the picture of the fresh outbreak.

Changes in the sacrum are liable to confusion by fæcal matter or gas in the pelvic colon, a source of fallacy which is got over by taking radiograms at intervals of two or three days.

Changes in the bones entering into the *sacro-iliac joint* are easily demonstrated; even small sequestra are readily recognized.

The origin and course of *sinuses* can be demonstrated by injecting them with some opaque material before the radiograms are taken.

The treatment of Pott's disease consists in a combination of the antituberculous regimen together with measures directed toward protecting the diseased segment of the spine from pressure and strain. It is our aim to bring about a cure of the tuberculous lesion without deformity. We shall not describe the familiar therapeutic measures but restrict ourselves to a brief résumé of recent methods. The most important of these is the securing of *rapid fixation of the spine by operative measures.* Albee of New York splits the spinous processes of the diseased vertebræ, and of a normal one above and below, and inserts a rod of bone derived from the tibia. The interspinous ligaments are also divided in the middle line, and along with the muscular aponeuroses are united over the graft with stout catgut. No mechanical support is used; after lying supine for six or seven weeks, the patient is allowed to go about. He has operated in 145 cases and has been uniformly successful in securing bony fixation. If angular curvature already exists, the tibial graft is notched at intervals to permit of its being bent, or the curve is gradually straightened out by Calot's method—a succession of plaster jackets with a window over the gibbus through which pads of cotton wool are inserted to exercise pressure upon it; the grafting operation is performed when the curve has been corrected. Hibbs fractures and displaces the spinous processes in order to bring about the desired osseous ankylosis.

Interference with the diseased vertebræ by operation has never attained any measure of popularity. The surgeon has restricted his efforts to the removal of a sequestrum that prevents the healing of a sinus, and to the evacuation of the contents of cold abscesses. Fischer and Müller of Rostock (Jourdain: Beiträge z. Klin. Chir., Band 82, 1913) have recently published the records of eight cases in which they operated by the *transperitoneal route for tuberculous disease of the lower lumbar and upper sacral vertebræ.* The access is described as much superior to the lumbar route, and the indications for its adoption are the removal of foci seen with the X-rays in the anterior part of the bodies, and the evacuation of a commencing abscess.

Syphilitic affections of the vertebral column are very rare, both in the acquired and inherited forms of the disease. Their chronic character and the tendency they exhibit to cause pressure upon the contents

of the spinal canal almost invariably result in their being regarded as tuberculous in origin. We are prepared to believe, although we have no knowledge, that the X-rays would yield valuable help in the differential diagnosis between syphilis and tubercle, and also in the recognition of other chronic affections such as *actinomycosis* and *hydatids*.

Brewer reports a case of *blastomycosis* of the vertebræ, with two separate foci in the spine and laminæ of the third dorsal vertebra and in two or three of the upper lumbar spines. Two operations were done and the man has remained well.

Charcot's disease, vertebral osteoarthropathy, is also very rare. Fosdick Jones has recently recorded two cases with instructive Röntgen pictures in the American Journal of Orthopedic Surgery, Vol. X, 1913.

Arthritis or spondylitis deformans is one of the commonest of lesions found in pathological collections. It affects many species of animals as well as man—oxen, horses, and the higher apes, for example—and the examination of prehistoric remains shows that the disease was widely spread among men and animals in far distant periods of human existence.

It causes pain in the affected vertebræ and referred along the nerve trunks; it is worse at night and is aggravated by movement; there is progressive limitation of movement, especially in the direction of extension and of lateral bending. The affected segment of the spine becomes abnormally "straight" and later presents a diffuse kyphosis without compensatory curves, and sometimes a lateral deviation as well. The intervertebral discs disappear, the spinal column loses in length, the bodies become ankylosed to one another by bridges of bone, and in the thoracic segment the ribs are also ankylosed to the vertebræ.

Formerly the disease was only recognized clinically when it had reached a comparatively advanced stage; now, with improved methods of skiagraphing the spine, the condition can be diagnosed by the progressive diminution of the intervals between the bodies and the characteristic bridges of bone uniting the vertebræ. In the later stages the Röntgen picture is obscured by the widespread formation of new bone. It is possible that artificial ankylosis of the spine, on the lines described in the treatment of Pott's disease, might relieve suffering and prevent curvature.

New Growths Arising in the Vertebræ.—*Primary tumors*, sarcoma, chondroma and myeloma, are among the rarities of surgery. In contrast to sarcomata of the long bones which especially affect young people, the vertebræ are more often affected after middle life, resembling in

this respect the other bones of the trunk and the skull. This age predilection figures in the diagnosis between the malignant spine and Pott's disease, because the latter affects almost exclusively children and adolescents.

The clinical history reveals some months of unexplained neuralgia, frequently followed by the gradual or sudden onset of paraplegia. *The early symptoms* are referable to pressure on the nerve roots: circumscribed unilateral neuralgia with hyperæsthesia and later anæsthesia; sometimes herpes zoster; rarely motor disturbances.

The *later symptoms* are referable to pressure on the spinal cord; unlike those which result from Pott's disease, they are not benefited by rest in bed or by weight extension. Tenderness on pressure and the projection of one or more spinous processes, when present, are of assistance in excluding disease originating in the spinal cord or in the membranes. We have observed cases in which long-standing and intractable sciatica, sometimes with Charcot's disease of the knee-joint, have followed upon sarcoma of the sacral vertebræ, a condition easily recognized by rectal examination.

Radiograms are often helpful in making the diagnosis, but the appearances presented vary so widely in different cases that no general rules for their interpretation can be formulated.

FIG. 196.—Skiagram of specimen of metastatic cancer in upper cervical spine. The spinal canal is encroached upon and there was paralysis of all four extremities. The patient had previously been operated upon for cancer of the breast. (*Dr. Hope Fowler.*)

Removal by operative measures

is out of the question, but an operation would be required if radium were to be inserted into the substance of the growth.

Secondary or metastatic carcinoma of the vertebral column is a comparatively common disease (Fig. 196).

The distribution of the metastases in the vertebral column reveals their origin through the blood stream; they are frequently multiple from the outset, are often distributed in vertebræ lying at a distance from one another, while the intermediate vertebræ and discs are free from cancer.

The bodies are the parts most frequently affected, although the arches and articular processes may also become the seat of cancer. Schlesinger gives the following table:

Breast,	10
Gullet,	9
Thyroid,	9
Bronchus,	5
Stomach,	4
Prostate,	3

It will be noted that primary bronchial carcinoma gives rise to metastases in the vertebræ relatively frequently. The virulence of the metastasis depends on that of the primary growth; it may develop very slowly, and if situated in the body frequently gives rise to no symptoms until there is a sudden collapse, with immediate paraplegia. The vertebra may be entirely replaced by the soft tissue of cancer or the cancer may assume an osteoplastic form as described by Recklinghausen, in which a considerable amount of new bone is formed. Still, whatever the form of the cancer, the spinal column is certain to undergo alterations. The column as a whole is weakened; it bends or kinks, or by telescoping becomes greatly shortened. One case is described in which the patient lost 9 cm. in eight months. There is rarely an angular curvature, usually a widely extended curve, convex backward, or backward and to one side. Metastases, however, may have existed for a long time and violent pains may be present without any visible alteration in the column. Pain on pressure over the diseased vertebra is often, but not invariably, present.

In its further growth the carcinoma projects the body of the vertebra forward and backward; the resistance of the disc seems to restrain the growth upward and downward; some time elapses before the cancer escapes and invades the surrounding tissues; the dura mater and the

nerve sheaths appear to offer a determined resistance to cancerous invasion.

The effect of the carcinoma upon the nerve elements is mainly exerted through a compression of the cord, but if it infiltrates the tissues outside the vertebræ it may involve nerve roots at a distance from their origin and the carcinoma may be localized too high up in consequence. There are all degrees of paresis and paralysis up to complete paraplegia; one of the earliest symptoms is violent pain due to the involvement of the sensory nerve roots, girdle pain, sciatica, and sacral pains. The patients are mostly women. Some of the cases illustrate what is called *latent cancer*. After an excision of the breast for cancer, for example, years may elapse and the operation area may be absolutely free from recurrence when the vertebral cancer makes its appearance. As regards the diagnosis, it is easy when the primary cancer is recognised; If the primary growth be hidden, for example, in the prostate or bronchi, the nature of the disease is not recognized.

The sad fate of the majority of patients with carcinoma of the vertebral column has led Foerster and Tietze[1] to attempt to diminish their sufferings by operative measures; this may take the form of removal of the arches, scraping out of carcinomatous masses, resection of the posterior nerve roots, or a combination of these. As is well known, the pains are often so severe that large doses of morphin afford only temporary relief.

Resection of the nerve roots was performed in three cases and laminectomy with removal of carcinomatous masses in two cases. The relief of pain was remarkable and the paralytic phenomena were also greatly improved.

The authors recommend a combination of laminectomy with resection of nerve roots. Cases with obvious deformity of the spine would appear to be more favorable for laminectomy. Great care must be taken in the transport from the operating table to the bed; the patient is enveloped like a mummy in firm blankets, and several assistants take part in the lifting and carrying.

The vertebræ may become the seat of *malignant disease spread from adjacent parts*, such as the pharynx, the stomach, the pancreas or the rectum. Similarly the bodies of the vertebræ may become eroded by the pressure of an aortic aneurism, thoracic or abdominal.

Deviations of the Spinal Column.—A vast number of conditions fall to be included under this head. When the balance of the body in

[1] Beiträge zur Klin. Chir., Vol. 73, 1911.

the upright position is disturbed at any point, it is restored by the mobility of the vertebral column which deviates or inclines from its normal axis until compensation is attained. Asymmetrical formation of a vertebra, for example, results in a lateral deviation of the spine above and below the seat of the lesion, a *congenital form of scoliosis*. Shortening of one leg causes obliquity of the pelvis, to compensate for which the spine deviates laterally, an *acquired form of scoliosis*. Flexion contraction of the hip causes an antero-posterior tilting of the pelvis and a corresponding increase in the anterior curvature of the lumbar spine, *an acquired form of lordosis*. These compensatory curves disappear if the cause of the deviation can be eliminated; if tilting of the pelvis be corrected, for example, the axis of the spine returns to the normal.

Temporary deviations are sometimes brought about by painful affections, in which relief is sought by inclining the spine so as to relax the affected tissues; in sciatica, for example, the patient may tilt the pelvis and incline the spine laterally, a condition known as *scoliosis ischiadica*.

The *habitual form of scoliosis*, so commonly met with in young girls, is a most important deformity of the spine. The primary curve is nearly always in the dorsal region, with its convexity to the right, with secondary or compensatory deviations in the cervical and lumbar regions with thin convexity to the left. With the lateral inclination, there is associated a rotation of the spine on its vertical axis, the bodies of the vertebræ facing the convexity of the curve and the spinous processes being directed toward the concavity. In the earlier period of the condition, the normal movements of the spine are retained and the deformity can be corrected, but in course of time, there ensue changes in the muscles, in the ligaments and in the bones as a result of which the spine becomes fixed in the deformed attitude (Fig. 197). The progress of the malady is attended by an increasing asymmetry of the vertebræ which is most marked at the summit of the curve; the bodies become wedge-shaped, the transverse and articular processes undergo corresponding changes, the intervertebral foramina become oval, the ribs on the concave side converge and narrow the intercostal spaces, while on the convex side they become more widely separated and project backward, forming the rib-hump. The sternum is displaced to the concave side and the cavity of the chest becomes markedly asymmetrical, the right half being greatly diminished so as to interfere with the expansion of the lung.

As the spinal canal is never encroached upon, the cord does not suffer.

The advanced stage of the deformity, which is usually well illustrated in museum preparations, is attended by the formation of new bones and *ankylosis* of the affected vertebræ; in some instances this is preceded

FIG. 197.—Skeleton of adult female, the subject of habitual scoliosis, showing the lateral curvature, with convexity to the right in the dorsal region and associated changes in the ribs and scapulæ, with compensatory curves to the left in the cervical and lumbar regions. (*Royal College of Surgeons, Edinburgh.*)

by a considerable posterior curvature of the spine, a condition described as *kyphoscoliosis*.

In the *etiology* of the habitual form of scoliosis, heredity plays a part, for the condition is sometimes met with in several members of the same family, but the determining factors in its production would

appear to be the repeated assumption of faulty attitudes in girls of delicate constitution who are growing rapidly and whose muscles, ligaments, and bones are unequal to the demands made upon them.

Treatment.—One of the first objects is the discovery of any cause of asymmetry, for if this be found and compensated for, most of the difficulties of treatment will have been overcome. Shortening of one leg will be compensated for by raising the sole and heel of the boot, while unilateral shortening of the trunk will in addition require a wedge-shaped pillow for sitting upon, so as to correct the tilting of the pelvis.

The purely habitual form of scoliosis is one of the most troublesome of maladies, unless it comes under observation and treatment at its very commencement.

Before the stage of bone deformity, gymnastic treatment is of great value; it includes of course training in how to stand, and how to sit, especially when reading and writing, and exercises of all kinds short of fatigue to develop the muscles both of the trunk and limbs and educate the muscular sense, and perception of equilibrium. Suitable exercises can be devised without apparatus of any kind; some authorities lay stress on creeping exercises—on all fours after the manner of a tiger—as specially valuable in fostering the mobility of the spinal column.

The child should be well nourished, should exercise for two hours daily, and should have long sleep, from 11 to 12 hours. The effect of the exercises is enhanced if they are preceded by a hot air bath to the back. The child is dressed in a bathing costume, the back portion of which is cut away down to the pelvis, while for the creeping exercises, the hands are protected by wearing gloves and the knees and points of toes with leather guards. The exercises should be carried out as much as possible in the open air, or failing this in well-ventilated rooms. In the intervals between the exercises, standing and sitting are forbidden and the child must lie on the back, belly or side. The most dangerous attitude is that employed in writing; the "oblique" writing should be exchanged for the "vertical" and a proper writing desk should be provided (Rudolph Klapp).

When there is definite bone deformity, exercises alone are a failure and recourse must be had to a rigid jacket which will permit of the correcting force being accurately applied; the wasting of muscles that attends upon confinement in a jacket must be disregarded until the bony deformity is corrected as it is quickly recovered from when the jacket is discontinued.

The jacket—made of dental plaster with 5 per cent. Portland cement

to increase its flexibility and durability (Sever)—is applied in the erect posture, head-traction being used so that the toes barely touch the floor. An accurate fit of the pelvis is essential; windows are cut on the concave side back and front to allow of the desired expansion and the pads are renewed weekly.

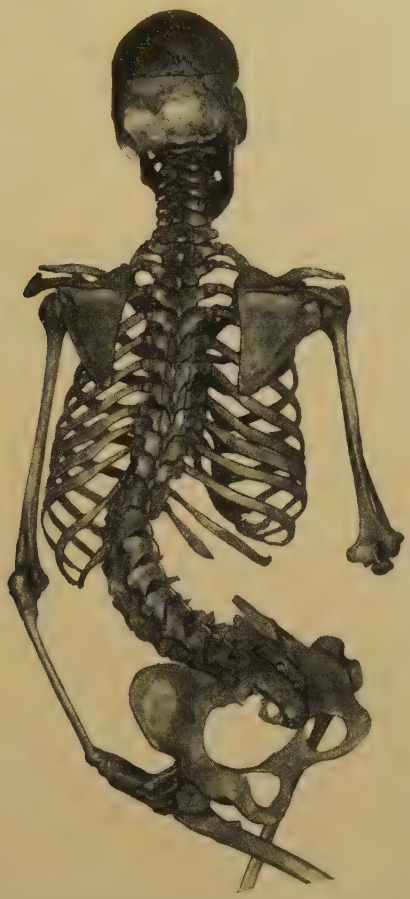

Fig. 198.—Skeleton of adult woman, who in infancy became the subject of bilateral hemiplegia (Little's disease). There is a pronounced rotation—lateral curvature, especially affecting the lumbar spine.

Abbott seeks to shorten the treatment by forcible correction of the bone deformity. The patient is slung in a bracket frame and by powerful traction the curve is undone and as far as possible over-corrected; while still in the frame, the plaster case is applied in the over-corrected position till the plaster has set. Over the former convexity three small windows are cut and pads of saddler's felt are inserted to undo the rota-

tion; a large window is also cut over the former concavity of the thorax.

Lovett, Calot and Royal Whitman are among those who approve of the Abbott method of treatment; they hold that it has been proved that as lateral curvature is essentially a flexion deformity, that the rotation should be more easily undone in the flexed than in the extended position, and that the deformity should be corrected before functional activity is permitted.

Abbott prescribes a plaster case for three or four months, and for six or seven months exercises and massage, the corset being still worn for 12 hours out of the 24 and always of course in the attitude of over-correction.

Scoliosis depending upon lesions of the brain and spinal cord in infants and children are practically beyond therapeutic correction and left to themselves are apt to drift into the condition illustrated in Fig. 198. At the time of onset of the paralysis, however, measures on lines similar to those employed in the extremities in cases of acute anterior poliomyelitis should be taken to prevent deformity.

SECTION XVII

DISEASES OF THE SPINAL CORD

By

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MALFORMATIONS

The only malformations of the spinal cord presenting any surgical importance are those known as *spina bifida* or *rachischisis*—a cleft of the neural arches, or much more rarely of the vertebral bodies, through which some or all of the contents of the spinal canal are liable to protrude. The bodies of the vertebræ are developed from the mesoblast and on their dorsal aspect the epiblast becomes inverted as a groove from which is developed the spinal cord. On each side of this groove there grows backward and ultimately inward a shelf of mesoblastic tissue, and these two shelves, uniting behind in the middle line, eventually form the pedicles, laminæ and spinous processes with the soft parts which connect them, then cutting off the epiblastic involution which forms the spinal cord and its central canal. This process of bony enclosure of the spinal cord is normally first completed in the dorsal region, whence it extends both upward and downward to the neck and to the lumbar region. In the normal individual the open end of the bony sacral canal alone indicates the original separation of the neural arches, but in spina bifida such separation may remain throughout a greater or less extent of the canal. In the anencephalous monster the formation of the epiblastic groove and canal may fail entirely and the neural arches will, therefore, be non-existent, but such conditions are of no practical surgical importance.

As to the *causation* of spina bifida little is known. On *a priori* grounds it would appear that such a condition might arise from (1) a primary hydromyelia or intravertebral dropsy preventing approximation of the neural arches, or (2) a primarily arrested development of the mesodermal tissue which is to constitute these arches. Clinically the frequent coexistence of hydrocephalus with spina bifida points rather to the former explanation, but the majority of pathologists appear to incline rather to the view that the essential factor is a failure in evolution of the mesoblastic covering, although no satisfactory explanation of such

failure is forthcoming. In the great majority of cases the cleft is, however, associated with some increase in length of the spinal cord and with an excess of cerebro-spinal fluid either in the meninges or in the central canal. It should also be remembered that spina bifida may be combined with other malformations some of which, such as hare-lip, appear to bear no pathological relation to it, while others, such as club-foot and congenital dislocation of the hip, may be the direct result of congenital deficiencies in the gray matter and consequent paralyses.

As regards extent, the cleft usually involves several adjacent vertebræ, the lumbo-sacral region being most commonly affected and the dorsal region least so. In extreme cases almost the entire spine may be involved, or on the other hand it may be limited to a single vertebra or even to a protrusion between two adjacent but intact arches. Very rarely two or even three separate clefts may be present.

As regards the *nature* of the protrusion, the following varieties of spina bifida are encountered:

1. A gap in the vertebral arches filled with soft tissue of mesoblastic origin and without protrusion of the cord or meninges is known as *spina bifida occulta.*

2. The dura mater and arachnoid are distended with fluid, forming a projecting sac which is known as a *meningocele;* rare and unimportant varieties of this type have also been described in which the distending fluid lies beneath the dura or between the two layers of the arachnoid.

3. The spinal cord or its nerve roots may accompany the meninges in the protrusion which is then known as a *myelomeningocele.*

4. In *hydromyelocele* or *syringomyelocele* the distending fluid occupies the central canal of the spinal cord of which the posterior part is stretched out to form a part of the sac wall.

5. The canal of the spinal cord may entirely fail to close so that the central canal lies open upon the back. In this condition, which is known as *myelocele* and to which the term rachischisis is sometimes restricted, the child is non-viable so that it has no surgical interest.

It is necessary to consider in a little more detail some of these varieties.

Spina bifida occulta is less rare than might be supposed as it does not always cause practical inconvenience and it often produces no visible protrusion. The lumbar or sacral region presents an area fn which one or more of the vertebral arches is absent, the gap being filled by a subcutaneous mass of fatty and fibrous tissue in which muscular fibers or fragments of bone may be discovered. The vertebral canal is of approxi-

mately normal size and contains as usual the spinal cord and nerve roots which may be quite normal or may be merely elongated. The skin covering the affected area is often thick and covered with hair which tends to assume a spiral curve or may present a small tail-like projection (Fig 199). If the condition persists in this form there is no functional disturbance and it may so continue throughout life, but in many cases the pad of fatty and other tissue tends to grow, forming a distinct tumor which projects externally to a slight extent and which also extends inward pressing upon the cord or cauda equina and producing the usual symptoms of paralysis and anæsthesia, symptoms which may arise at any time after birth and may not appear before adult life.

Fig. 199.—Trichiasis lumbalis with spina bifida occulta (Kellner). (*Keen's Surg.*)

In *meningocele* we find a definite rounded projection upon the back presenting all the usual characters of a cyst and due to distention by fluid which generally lies in the subarachnoid space and is, primarily at any rate, continuous with the cerebrospinal fluid of the rest of the subarachnoid area. The cord, which may again be lengthened, lies in its normal position and is unaffected. The skin over the sac is usually very thin and tense, often bluish in color and often bearing round its margins an exaggerated growth of hair. The sac is highly translucent and as its contents are in part reducible into the vertebral canal it can be compressed while on the other hand its size is increased by straining, crying and the assumption of an erect attitude. In some cases obliteration of the neck of the sac may occur and we then find a thin-walled cyst which has ceased to be associated with the nervous structures, or to present any evidences of distention or of reducibility.

Myelomeningocele is the commonest variety of spina bifida and constitutes about one-half of all cases met with (Figs. 200 and 201). The sac presents all the characters of a simple meningocele and certain additional features due to the presence of the cord which generally

occupies its posterior portion. Thus on examination by transmitted light it may be possible to see a darker band or bands lying across the translucent cyst and there is often a small depression or umbilication marking the attachment of the filum terminale. In the lumbosacral variety the cord terminates on the posterior aspect of the sac wall while the nerves of the cauda equina double back to pass out of the intervertebral foramina; in the rare cervical and dorsal forms the cord also passes to the posterior part of the sac and then returns to the spinal canal. In all cases the cord is lengthened and in very many it is flattened out so as to lose entirely its normal contour; it may be either free or adherent to the meningeal wall. In spite of these

FIG. 200.—Myelomeningocele.

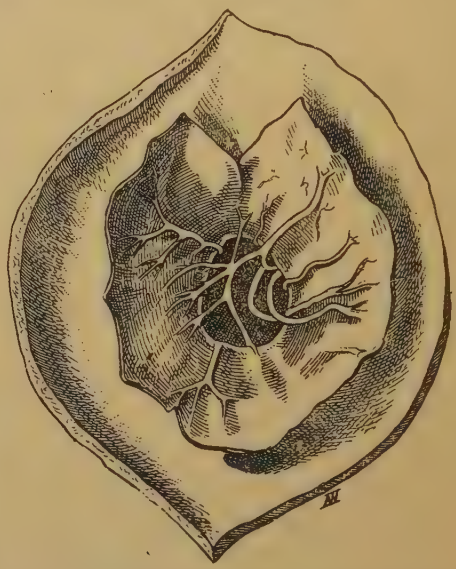

FIG. 201.—Myelomeningocele. (*Staimer-Marion.*)

conditions the medullary functions are, however, usually quite normal and it is only in connection with later cicatricial changes that paralyses are liable to be produced.

A *syringomyelocele* or *hydromyelocele* presents external characters similar to meningocele but the fluid collection now lies within the central canal and the wall of the sac contains nervous tissue more or less intimately blended with that of the meninges. The bulk of the spinal cord is, however, usually in front of the projection and only a thin sheet is spread out on its posterior aspect.

Spina bifida rarely remains for any length of time as a simple hernia of the meninges or cord. As it gradually enlarges, its thin

covering becomes more and more thinned and stretched out so that ulceration or rupture is very liable to occur, in which case there ensues a fatal septic meningitis, or the escape of cerebro-spinal fluid leads to rapid exhaustion and generally to death from convulsions. Less commonly but far more fortunately there may be gradual shrinking of the sac, its cutaneous surface may present a cicatricial appearance and spontaneous cure may ensue. In other cases cicatricial bands form within the sac which may thus become multilocular or may be entirely cut off from the general meningeal cavity, while some changes may in the case of a meningomyelocele lead to pressure upon the enclosed cord with paralytic conditions similar to those met with in spina bifida occulta.

The general *prognosis* of spina bifida may then be summed up as follows:

In spina bifida occulta, life is not directly threatened and the condition is often not discovered in infancy, but pressure symptoms are very liable to develop although these may not appear until many years after birth. In myelocele the child is not viable, while syringomyelocele is probably hopeless. The more important and typical varieties of meningocele and myelomeningocele are very liable to cause death, but occasionally undergo spontaneous cicatrization and recovery which may again lead to pressure upon the cord or cauda equina; in these cases also it is common to meet with hydrocephalus with its attendant dangers:

The *treatment* of spina bifida occulta and of cicatricial conditions due to healing of other varieties of rachischisis consists in the removal of the source of pressure and does not differ essentially from the treatment by laminectomy of other pressure lesions. It is generally necessary to remove at least one complete lamina, preferably above the gap, and, having thus determined the position of the meningeal canal, the surgeon has to dissect off the cicatricial or hyperplastic tissue. Such an operation often presents great technical difficulties, but if carefully carried out yields very satisfactory results although we have never seen complete recovery from nervous symptoms.

In meningocele and myelomeningocele we have, however, to deal with a rapidly progressive lesion directly threatening life and we may adopt one or other of several methods which aim at producing obliteration of the sac, while in all cases we must protect the latter from external injury. Palliative or expectant treatment will consist in painting the thin wall of the sac with a coating of collodion or com-

pound tincture of benzoin which may be reinforced by a thin piece of gauze; the sac is then surrounded by a ring cushion or covered by a wire shield so as to remove the danger of pressure;[1] and great care is exercised in cleaning and drying the parts. Such measures should be adopted from the moment of birth and as already indicated will in some cases be followed by spontaneous cicatrization; at least they will assist nature's effort and may allow the child to pass through the earlier months or years of its life and so place it in a more favorable position for subsequent operation.

Assuming that when the case is brought before the notice of the surgeon there are no immediately impending fatal complications he will, however, have to consider whether or not it is one suitable for operation and what form of operation he will adopt, remembering that many cases will never come within the reach of surgery, that many others will be obviously hopeless, that some will recover spontaneously and that it is only by judicious selection that any satisfactory results can be obtained. In all cases age is a feature of much importance: on the one hand all the more radical operations are associated with considerable shock and should, therefore, be deferred as long as possible and rarely undertaken before the end of the first year of life; on the other hand the first year is the period of greatest danger from ulceration and sepsis while delay will increase the difficulty of replacing the spinal cord in its bony canal. Broadly, therefore, it is important to operate early but early operations must be of the simplest type and it may be possible by occasional aspiration of the sac to temporize and allow of more radical procedures at a later date. With such reservations we may then divide cases into those which are and those which are not suitable for operation. The favorable cases will be (1) those in which the sac is of moderate size or slow growth with few or simple nervous connections and with intact or comparatively healthy coverings and (2) those which remain stationary or which, after spontaneous retrogression cease, to improve. The unfavorable cases are (1) large sacs with leaking contents or extensive ulceration in which sepsis will almost certainly follow any surgical treatment and (2) cases of marked general marasmus, severe hydrocephalus or paralysis of the lower limbs, bladder, etc. Cases presenting small sacs with good cutaneous covering and marked tendency to contract do not require operation.

The available operations are:

[1] A convenient covering is half of a tennis ball lined with lint and kept in position by tapes.

1. Injection of the sac.
2. Excision of the sac.
3. Plastic operations.
4. In cases associated with hydrocephalus lumbar decompression with permanent drainage of the meninges into the peritoneum is practised by Cushing.

Of these the first is the simplest and is best adapted to the very young but is less certain in its results than excision. The more elaborate plastic operations again are possible only in exceptionally favorable conditions and in older children. We may, therefore, regard simple excision as the typical method, reserving injection for younger and more urgent cases and plastic methods for the older patients.

Injection was perfected by Morton, whose name is generally attached to the operation which consists in introducing a solution (Morton's fluid) consisting of 10 grains of iodine, 30 grains of potassium iodide and an ounce of glycerine whose value as a vehicle depends on its slow diffusibility. The parts being thoroughly cleaned, the child is anæsthetized with chloroform and placed upon its side with the head low so as to diminish the tension within the sac. A needle sufficiently large to permit of the flow of glycerine is then introduced, care being taken to avoid any obvious nervous structures and to enter from the periphery of the sac so as to penetrate the thickest and most healthy skin. If the contents be very tense, 1 or 2 drams may be allowed to escape and then from 30 to 60 drops of the fluid are injected; the needle is withdrawn, the aperture is sealed with collodion and a pad of cotton wool is applied. The child should then be kept upon its side for a few hours to diminish the tension within the sac and thereafter should lie upon its back. Several injections at intervals of 10 to 14 days are usually required. In successful cases the sac will gradually shrink and become obliterated; in others no result will be obtained and in some there will follow leakage and meningitis. Sometimes also cicatrization may be followed by paralysis or by hydrocephalus as in the spontaneous "recoveries." Probably about one-half of all cases are cured.

Incision of the sac has seldom been successful in children under 12 months of age and should not be attempted in the presence of extensive ulceration, leakage of cerebro-spinal fluid, hydrocephalus or marked paralysis. Every precaution is taken against shock; the parts are carefully sterilized and small patches of ulceration are touched with some strong antiseptic such as pure carbolic acid. The child, anæsthetized with chloroform, is placed upon the face with the head low.

Two elliptical incisions are now made over the sac, sufficiently far from its center to include any skin which is too thin for subsequent healing but leaving enough margin to form flaps which will meet without any tension (Fig. 202). If there is not sufficient sound skin to allow of this being done, additional parallel incisions may be made further out so as to allow of the gliding inward of the flaps. Unless the sac be very close to the anus these incisions will be made vertically and if possible one flap should be made larger than the other so as to lateralize the line of suture. The skin flaps are then very carefully peeled off the sac, the greatest care being taken not to rupture the latter. If now the sac is a pure

Fig. 202.—Spina bifida. Incisions for excision of the sac. The dotted lines indicate the incisions which may be necessary to allow approximation of the flaps. (*Thorburn. Burghard's Op. Surg.*)

meningocele with a narrow neck, it may suffice to ligature the latter and cut away the protruding meninges. Far more commonly, however, the sac must be opened and its contents carefully dealt with and in so doing it is necessary to avoid a sudden gush of its contents. The neck is temporarily compressed with a plug of gauze and a small opening is so made as to avoid any nervous structures. After the fluid has gradually run away this puncture is converted into a free incision which should also be lateralized so as not to coincide with the line of the skin incision. It is now necessary to separate all nervous structures from the sac wall which requires extremely careful blunt dissection. In

case of very strong adhesions it is better to leave fragments of the sac attached to the nerves than to risk injury of the latter and no bands should be regarded as cicatricial or cut away until the operator is quite certain that they are solely fibrous. The nervous structures are then gently returned to the spinal canal, the redundant sac is cut away and the incision into it is closed with a continuous suture of fine catgut. The skin wound is best closed by mattress sutures so as to give broad apposition with final accurate closure of the epithelial edges. No drainage must be used. The wound is sealed with collodion and covered with wool and for several days the child is kept with its head low so as to throw the least possible tension upon the recently closed sac. Of cases treated by this method probably about one-half are fatal but in those which survive the results are very good.

The plastic operations which have been devised with a view to more complete closure of the bony defect in the spine are numerous and in some cases complicated. They present the advantage of diminishing the risk of leakage but the disadvantage of involving more shock than simple excision and it is hardly practicable to do more than indicate the main varieties, as the selection in any particular case must depend upon the available amount of bony or other tissue and on the surgeon's judgment as to how far it is safe to carry out complicated manipulations. The more important types may be classified as follows: I. The sac after being cleared, opened and freed from its contents, is not cut away but folded up into a plug which is sutured into the spinal gap. II. After the sac has been excised and sutured, the skin flaps are undercut for a distance of about an inch on each side of the cleft until the vertebral aponeurosis is exposed. Two vertical lateral incisions in the latter allow it to be raised by blunt dissection in the form of two bridges similar to the flaps made in the ordinary operation for cleft palate and the fibrous or fibromuscular bridges thus formed are sutured together in the middle line. III. If the laminæ on each side of the cleft are not too rudimentary their bases may be cut across and similar bridges thus obtained consisting of the laminæ and all connected soft parts. IV. A flap has been made by dissecting off a portion of one iliac bone, leaving intact the periosteum at its inner side and then turning the flap over on its periosteum so as to cover the gap. V. Plates of foreign (heteroplastic) bone or periosteum, celluloid plates, ivory and silver foil have been implanted.

As to the general prognosis of operation for spina bifida, no extensive and reliable figures are obtainable, but there can be little doubt

that many cases die even among the comparatively few in whom operation is possible. A recovery rate of about one-third is perhaps all that can at present be expected.

INJURIES

The spinal cord and its meninges are so thoroughly protected by the arches of the vertebræ that they are rarely injured save in association with fracture or dislocation of the spine, which has been considered in a previous section, but occasionally punctured wounds may enter the vertebral canal without such injury to its walls, and in some cases hematomyelia may be caused by acute flexion of the spine without obvious lesion of its bones or joints. Moreover in cases of fracture and dislocation, the injury to the cord is of far more serious importance than is that of the bones, and hence it has been considered advisable to deal in this section with all injuries of the *contents* of the vertebral canal, referring incidentally only to its bony coverings. Before proceeding to such consideration it will, however, be useful to recall a few points in connection with the anatomical relations of the parts concerned.

Under normal conditions the theca spinalis and its contained meningeal space extend down the back only as far as the second sacral vertebra, while the spinal cord itself terminates at the lower border of the first lumbar vertebra and is thus much shorter than the spinal column. As the nerve roots in connection with each medullary segment pass down within the theca to their exit from the intervertebral foramina they have necessarily a somewhat extensive intravertebral course which gradually increases from above downward, reaching its extreme limit in the case of the cauda equina. It follows that in an injury of the bony spine at any point we shall have an injury of that segment of the cord which lies opposite to it and which will often be considerably lower than the segment bearing the corresponding number, and it is thus necessary to bear carefully in mind the relative association of the two structures.

The brachial enlargement of the cord, comprising segments from the fourth cervical to the first dorsal, lies beneath the third, fourth, fifth, sixth and seventh cervical spinous processes. The lumbar segments lie beneath the ninth or tenth and eleventh and twelfth dorsal spines and the sacral segments beneath the twelfth dorsal and first lumbar spines. In somewhat fuller detail we may say that in the

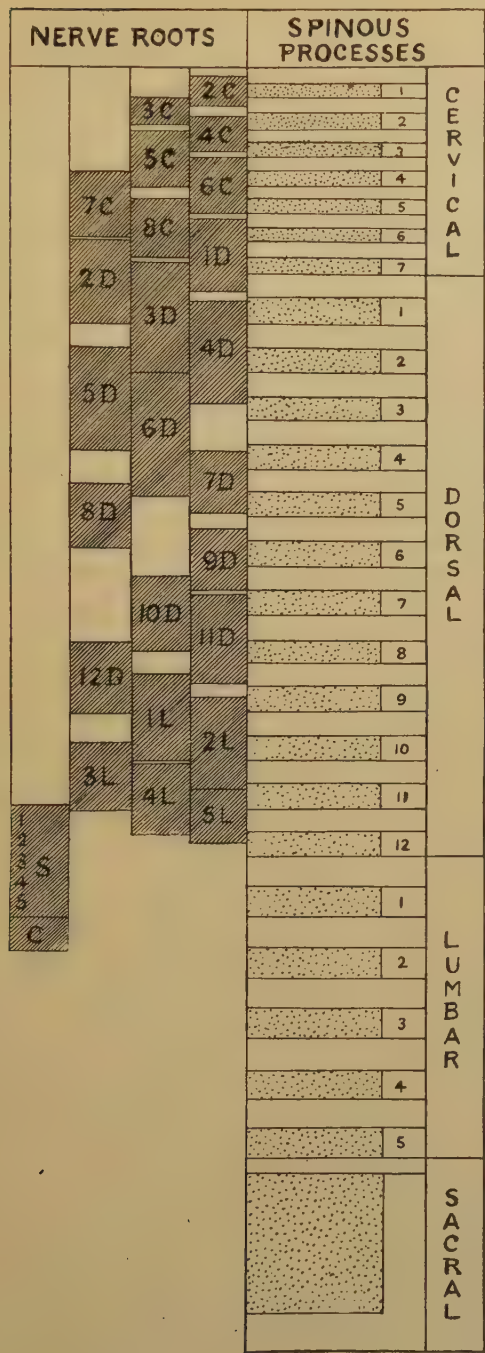

FIG. 203.—A diagram indicating the variations in the relationship of the origin of the nerve roots to the apices of the spinous processes. The dotted areas indicate the vertical extent of each process; the areas shaded in lines indicate the extreme variations of origin of each root. Thus, the sixth dorsal root may leave the cord at any point from the lower border of the second dorsal spine to the upper border of the fifth. (*Thorburn, modified from Reid, Burghard's Operative Surgery.*)

neck each cord segment lies higher than the tip of the correspondingly named spinous process by the depth of about one vertebra; in the dorsal region each cord segment lies under the spinous process of the second or (lower down) of the third vertebra above that which bears the same name, so that, for example, the twelfth dorsal segment is beneath the ninth dorsal spine; and finally, all the lumbar and sacral segments are crowded together beneath the last three dorsal and first lumbar spines, below which we have only the cauda equina. These relations have been fully worked out by Reid and the annexed diagram (Fig. 203), modified from his work, illustrates the widest variations met with at different levels.

Before passing from this question of the relation of the cord to the spine we may also note that the nerve roots are more resistant to injury than is the cord itself and that they possess a greater power of repair. Thus injuries of the cauda equina are less serious than those of the medulla, with respect to which latter there is a total want of evidence that in the higher mammalia it possesses any capacity whatever for regeneration.

Penetrating wounds of the cord and meninges other than gunshot wounds are very rare but are occasionally due to accidental or especially to homicidal stabs and cuts. Most common in the neck and least so in the loin, where the bony protection is most perfect, they are generally due to stabs in the back, although the cervical cord has occasionally been injured from the front as in a case of an umbrella wire which passed through the pharynx and penetrated between two vertebræ. An analysis of a number of reported cases shows that the lesion commonly involves only one-half of the cord, the stab passing obliquely on one side of a spinous process and the fact that the right side is cut twice as often as the left is doubtless due to the direction in which a knife thrust will naturally be given by a right-handed man striking from behind.

In a few of these cases the nervous structures have escaped and there has been a wound of the meninges only indicated by a flow of cerebrospinal fluid, which may be profuse and continuous and which has been mistaken for urine coming from a wound of the ureter. Apart from such flow or from secondary infection meningeal wounds are, however, not very likely to be recognized. They present no serious symptoms and their only importance lies in the danger of subsequent meningitis, a danger which calls for exploration in all suspected cases, and, if necessary, for suture of the theca and drainage of the external wound.

The cord lesion when present, being usually a more or less complete hemisection, presents an admirable picture of "Brown Séquard's paralysis" or homolateral hemiplegia with contralateral anæsthesia to touch, and such cases are of the greater value to the neurologist as they may occur at very high levels, two at least having involved the medulla oblongata. The prognosis of these injuries *quoad vitam* is less serious than might be anticipated, two-fifths of those recorded having survived, although in all there has remained some permanent paralysis or anæsthesia. The usual course of events is highly instructive as to the results of other injuries to the cord. The early symptoms are extensive and often bilateral, resembling those found in crushes of the spinal cord and in hematomyelia, but as the lesion is generally less complete the more severe respiratory, vesical and trophic troubles do not appear. There generally follows considerable improvement due no doubt to the absorption of hemorrhage and the relief of consequent pressure upon the ascending and descending fibers of the cord and then there remains a "stationary condition" of the crossed paralysis and anæsthesia as already described. That under these favorable conditions, in which separation is inflicted by a sharp instrument which does not wholly sever the cord, recovery should be so incomplete, indicates very clearly how little, if any, power of repair is possessed by the nervous structures of the medulla and, further, it is important to note that, although there is an obvious danger of septic meningitis and death, comparatively few cases have so ended, and the majority survive in a more or less crippled condition.

The treatment of such cases should unquestionably be operative. The wound of the soft parts should be opened up, and as far as possible disinfected, the adjacent laminæ are then wholly or partially removed and the meninges sutured. Nerve roots, especially in the case of the cauda equina, have also been successfully sutured but the writer is unconvinced by a few reported cases that anything is to be gained by suturing the irreparable spinal cord and he would fear that the passage of the needle and of the sutures themselves would only increase the injury.

Tears and crushes of the meninges such as result from all forms of fracture, including gunshot wounds, are followed by hematorrachis or hemorrhage into and around the theca with consequent pressure upon the spinal cord and they produce symptoms which may closely resemble, and may at first be impossible to distinguish from, those of crushes of the cord itself. In one rare variety which we have called "gravitating

hemorrhage" there is, however, no difficulty in establishing a diagnosis. In these cases the effused blood gravitates freely to the bottom of the theca and, collecting at its lower end, produces an ascending paralysis of which a few instances have been recorded. A lumbar puncture would in such cases doubtless confirm the diagnosis and to some extent relieve the symptoms, but all cases of serious pressure by thecal or perithecal hemorrhage will demand operation by laminectomy, and for all practical purposes they may, therefore, be considered in connection with the injuries of the spinal cord.

Contusions and Crushes of the Spinal Cord.—We have already seen that the spinal cord is not commonly injured except in connection with some form of fracture or dislocation of the vertebræ or with gunshot wounds penetrating between the laminæ, although in some cases hemorrhage may result from trauma in the entire absence of any evidence of injury to the spine. It will, however, generally be found that such are due to over-flexion of the spine, and it is probable that they have been produced by *diastasis* or by acute angular displacement which with momentary dislocation has immediately recoiled, leaving as its only trace a bruise of and a hemorrhage into the medulla. Moreover, radiographic examination has shown that fracture-dislocation may occur in all regions of the spine without producing obvious symptoms of injury to that structure and with the advent of the skiagram the number of examples of traumatic hematomyelia showing no bony lesion has undoubtedly diminished. Probably, therefore, in all such cases there is a primary injury to the vertebral column and as these injuries have been fully dealt with in another section we shall here consider under one heading all forms of contusion, crush and gunshot wound of the cord without regard to the mechanics of their production. We must also recognize that nerve roots are liable to be crushed along with the cord although their injury has comparatively little practical importance except in the case of the cauda equina.

Crushes are met with in the whole length of the spinal cord but are especially liable to occur in the lower cervical region and about the dorsolumbar junction, both because the cord is here expanded by the brachial and lumbar enlargements, so that it has less room in the canal and because these are regions mechanically liable to injury. In the cervical region especially we often meet with crushes unaccompanied by obvious or permanent bony displacement, this region being peculiarly liable to recoil after over-flexion.

The contused area presents a hemorrhage of varying extent which

may run directly across the cord or may be oblique so as to extend higher upon one side by the distance of one or more segments (Fig. 204). As a rule this hemorrhage is more extensive in the center than in the periphery of the cord and it tends to run upward and downward in the central canal producing a spindle-shaped area which may be 1 or 2 in. in length. In other cases the cord is completely torn across and its ends may be widely separated especially in gunshot wounds. The meninges may or may not be torn and the nerve root lying alongside of the cord usually suffer less than the medulla itself although their injury may cause paralysis in the distribution of one or more segments above that of the actual cord lesion.

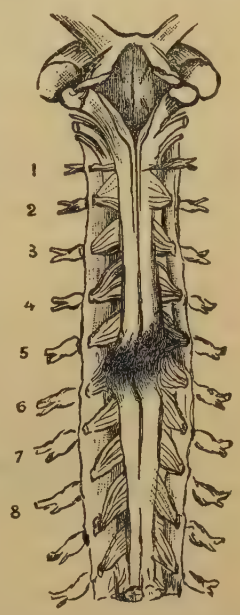

FIG. 204.—Spinal cord from a case of comminuted fracture of the 5th and 6th cervical vertebræ. View from behind showing compression, extending obliquely from above the origin of the 5th cervical nerve on the left side, upwards, so as to intercept the 5th nerve root on the right side.

The early hemorrhage is followed by two changes antagonistic in their results and materially affecting the progress of the case. On the one hand blood tends to become absorbed and, if the patient survive, there is a gradual improvement in symptoms. A part only of the spinal cells and fibers has been crushed out of existence; a part is merely compressed by blood and the pressure lesion tends to recovery while the crushed area does not but causes the "stationary condition" which may only be reached after some days or weeks. On the other hand, the primary lesion is followed by softening or traumatic myelitis which tends to spread upward for a few days after the injury so that we can commonly observe the upward march of paralysis for a distance of from one to three segments. It is this extension of the lesion which renders so many crushes in the cervical region fatal. These crushes most commonly affect the fifth or sixth cervical segments but, spreading up to the fourth and third, involve the origin of the phrenic nerve and terminate the patient's life. In addition to the more localized changes which determine extension or retrogression of paralysis, injuries are also associated with ascending and descending sclerotic changes in the conducting fibers of the cord, such changes producing system degenerations as does any other form of myelitis. There is no evidence that those portions of the cord actually crushed are ever regenerated and in

all cases some cicatrix remains. In cases which survive long enough—and especially, therefore, in injuries of the dorsal and lumbar regions—the cord and meninges may be converted into one uniform fibrous cord, and again in some cases of incomplete crushing the meningeal or perimeningeal tissue gives rise to a cicatrix which by continued growth or more probably by contraction, produces a gradually increasing paralysis analogous to that resulting from the pressure of tumors or of tuberculous or syphilitic deposits.

The *symptoms* of a crush of the spinal cord will differ very widely in different regions, but may first be considered collectively. Apart from initial shock we may look for and we shall generally find paralysis, spasm, anæsthesia, hyperæsthesia, affection of the centers for the

Fig. 205.

bladder and rectum, changes in the superficial and deep reflexes, vasomotor phenomena, and "trophic" changes.

Paralysis may be due either to injury to the gray matter of one or more segments or to crushing of or pressure upon the descending motor fibers, as they pass through the affected segment. Hence in minor injuries it may be limited to the distribution of those segments actually crushed, while in a complete rupture it will involve all muscles supplied from below the level of the injury. Hence, also, it assumes an atrophic type in the segments crushed and a spastic type below them. Its completeness and persistence will be principally determined by the extent of the crush, but for a few days it may often be increased by the spread of softening or at a later date it may be diminished as effused blood is gradually absorbed.

Spasm is met with under two conditions. On the one hand, it is common to find marked contraction of the muscles supplied from immediately above the paralyzed area. How far this is due to mere unopposed physiological tonus and how far to a more active change associated with the spread of softening we do not know, but the condition of muscular contraction produces in many cases fixed and highly characteristic attitudes, as shown in Fig. 205, where a crush involving the sixth cervical segment leaves in action the muscle supplied by the fourth and fifth (infra) and produces abduction and external rotation of the arms with flexion of the elbows. Another variety of spasm is met with as a result of descending degeneration in the lateral tracts; it affects the muscles below the crush and is associated with the exaggeration of deep reflexes characteristic of all transverse spinal lesions. Unlike the spasm above the lesion, this condition is permanent and probably reflex in nature.

Anæsthesia like paralysis presents the widest differences of intensity and distribution. In complete crushes it extends fully up to the level of the lesion and involves all forms of sensation. In injuries of less severity it presents no sharp upper margin but often fades away toward the upper part of the affected area, while it also presents the dissociation phenomena common to other forms of myelitis, analgesia and thermal anæsthesia generally extending higher than the loss of tactile sense. Like paralysis it tends for a day or two to spread upward as softening progresses, while at a later date it often gradually decreases and may disappear. In complete crushes it is, however, permanent and absolute.

Hyperæsthesia and pain are found above the level of anæsthesia, usually in the form of a more or less definite band passing round the trunk or down the limbs. These conditions are probably due to irritation of nerve roots by pressure or possibly by myelitic softening, but so far as the writer is aware the cord itself is insensitive, and it may generally be assumed that hyperæsthesia indicates that the affected segment is not destroyed but that the nerve roots only are pressed upon, for which reasons the condition is seldom persistent.

The functions of the *bladder* are affected in all complete crushes and temporarily, at least, in the majority of even the slighter cases. The most characteristic result is retention of urine due to paralysis, but in old-standing cases we may find spasmodic incontinence. Retention, if prolonged and unrelieved by the catheter, is necessarily followed by overflow, and in the great majority of cases there will ensue cystitis

with probably eventually pyelitis from ascending infection. The tendency to cystitis is also very greatly increased by the vasomotor or trophic change to which we shall refer immediately, and the result is a most severe inflammation, often of a hemorrhagic type, with sloughing of the mucous membrane of the bladder and the formation of points of suppuration in the kidneys. From this condition we often have early death, or in other cases a more chronic inflammation ensues and again proves fatal after weeks or months.

The *rectum* is also paralyzed and control over the bowel is lost. The actual result as regards constipation or diarrhœa will, however, depend upon many factors such as the condition of the intestinal secretions and the expulsive power of the abdominal wall. In the early stages there is generally intestinal paralysis and constipation, but after a few days fæces pass without the control or knowledge of the patient and the bowel merely empties itself as from an artificial anus.

In complete crushes the *deep reflexes* are abolished and their total loss may almost be taken as evidence of the fact that a section of the cord is entirely destroyed. In less severe lesions when some motor or sensory power is retained they are usually exaggerated and this exaggeration tends to increase with the incidence of descending degeneration. It is associated with a marked tendency to extreme spasm upon the slightest cutaneous or other irritation. The conditon of the *skin reflexes* presents so much variation as to have little if any practical importance except that an extensor reflex on stroking the sole accompanies exaggeration of the deep reflexes. The skin reflexes are of course abolished in those areas whose segments are destroyed.

Vasomotor changes are well marked but have been scantily investigated. As regards the skin it would appear that the vessels are constricted as indicated by a lowered surface temperature and by extreme dryness with scaliness of the epidermis. The distal vasomotor mechanisms, cut off from the medulla oblongata, are, however, readily disturbed and stimulation of the skin easily causes flushing and a rise of temperature. In the case of the highly specialized vasomotor arrangements of the penis these changes are manifested by *priapism* which is most commonly observed in the case of injuries of the cervical and upper dorsal cord and which takes the form of turgidity rather than of complete erection—*i.e.*, of paralysis of vasomotor control. In the female a profuse vaginal secretion is generally met with and is probably due to vascular conditions similar to those inducing priapism. In the case of injuries to the cervical cord the writer has also found

interesting variations in the condition of the *retinal vessels* which appear to be out of control as are those of the skin and to this we may probably attribute the occurrence of optic neuritis in various affections of the cervical cord, the vasomotor nerves for the retina presumably passing through the inferior ciliospinal center (*infra*, p. 610).

In connection with vasomotor phenomena it is convenient to refer to *hyperpyrexia* although the pathological basis of this condition is not fully understood. The commonly observed fact is that in cervical injuries when paralysis extends upward to about the fourth segment, the patient rapidly develops a temperature which often reaches to 105°F. and not rarely to a still higher point. This condition is commonly met with about the second or third day after the injury and is usually fatal within about 24 hours so that in a long experience we have only once seen a subsidence of pyrexia following an injury to the cervical cord. It is often associated with pneumonia but not invariably so.

The "*trophic changes*" of spinal injuries are numerous and important but they are largely explicable by the association of vasomotor changes with paralysis and anæsthesia and they provide no evidence in favor of the existence of special trophic nerves. In the case of voluntary muscles extreme atrophy occurs in the distribution of the actually crushed segment or segments. The bladder is, as already noted, prone to the development of an acute and severe cystitis which is often the direct cause of death in injuries of the lower parts of the cord. In injuries which involve the cervical and upper dorsal regions, the intercostal nerves are paralyzed and in association therewith it is common to meet with broncho-pneumonia which again is a most fatal complication. Injury involving the fourth cervical segment, either primarily or by softening, almost invariably produces extreme respiratory paralysis and pulmonary congestion or inflammation. *Bedsores* result from the paralysis preventing change of position from anæsthesia preventing local discomfort or the desire to relieve pressure, from irritation by escaping urine and fæces with consequent inunction of septic material, and finally from the unstable vascular condition of the skin. In many cases such bedsores are found on all points of pressure and are not limited to the back but involve also the heels and angles of the scapulæ. They are exceedingly intractable, presenting very little tendency to heal even under favorable conditions. They burrow deeply and like other complications of spinal injury they are often fatal. *Joint lesions* are occasionally met with especially in

the knees but are usually a late phenomenon and we are inclined to regard those cases which we have met with as probably due to septic infection from the urinary organs or from bedsores rather than to any "trophic" change. The usual type is a subacute synovitis without marked bony changes but associated with some swelling, redness and local rise of temperature; pain is absent as the region is anæsthetic. The prognosis of such conditions is not unfavorable. Many recover if the patient survives although some cicatricial change and stiffness will remain with or without deformity. Suppuration is extremely rare and has not occurred in our experience.

Finally we may refer to *tympanites* which commonly appears in cervical and dorsal injuries and which results from paralysis of the abdominal muscles and possibly from vascular and secretory changes in the intestines. Other manifestations of disturbed secretion such as occasional albuminuria, polyuria, glycosuria and the like are so rare and so little studied as hardly to present any practical importance.

Having considered the general symptoms of a crush of the spinal cord we may now review in a little more detail the regional variations which these present. The entire cord is divisible in a series of segments each of which has a definite relation to certain muscles and cutaneous areas. Thus, if a complete crush occur through any segment, paralysis will involve the muscles supplied by that and by all subjacent segments and anæsthesia will similarly involve the cutaneous regions connected with it and all subjacent segments. In less severe crushes paralysis is often absolute only in the distribution of the affected segment and a certain amount of power may be retained in those below, there being a tendency for such motor power to improve as we pass downward from the injured region. In the case of anæsthesia, on the other hand, the more distal parts suffer more than those nearer to the lesion and the upper border of the sensory loss thus tends to present a fading margin. It must not, however, be supposed that each muscle or each cutaneous area is connected with one segment only. There is a good deal of overlap and most muscles receive fibers from two or more adjacent segments. In spite of this it is possible to recognize the principal segmental association of each muscle and we may enumerate the various segments with the muscles which they essentially supply in accordance with the following table:[1]

[1] This table is to be regarded as a compilation from the work of various writers, and not as expressing in all cases the personal observations of the writer. So far as possible all doubtful cases are entirely omitted, and those muscles only are named whose condition may fairly be relied upon for purposes of diagnosis. In the case of the lower lumbar and upper sacral segments especially, there is still much uncertainty.

Cervical I.—Small muscles of neck and distribution of descendens noni nerve.

Cervical II and III.—Diaphragm, sterno-mastoid, trapezius.

Cercival IV.—Diaphragm, supraspinatus, infraspinatus.

Cervical V.—Biceps, brachialis anticus, deltoid, supinator longus, supinator brevis.

Cervical VI.—Subscapularis, pronator quadratus, pronator radii teres, teres major, latissimus dorsi, pectoralis major, serratus magnus, triceps.

Cervical VII.—Long extensors of the wrist and fingers, secondary supply of many of the muscles of the sixth segment, and of flexors of the wrist and fingers.

Cervical VIII.—Long flexors of the wrist and fingers.

Dorsal I.—Intrinsic muscles of the hand.

Dorsal II to XII.—Intercostals and abdominal muscles.

Lumbar I.—Abdominal muscles.

Lumbar II.—Abdominal muscles, cremaster, psoas(?), iliacus(?), sartorius(?).

Lumbar III.—Adductors, psoas, iliacus, sartorius.

Lumbar IV.—Quadriceps femoris, glutei, obturator externus.

Lumbar V.—Hamstring muscles, glutei.

Sacral I.—Muscles of calf, gluteus maximus.

Sacral II.—Extensors and flexors of the ankle and toes, peronei, intrinsic muscles of the foot.

Sacral III.—Perineal muscles, intrinsic muscles of the foot.

Sacral IV and V.—Bladder and rectum.

The sensory distribution of the segments is more readily represented in diagrams than in words and is illustrated by the following figures:

It will be noted that in these figures the root areas are not drawn symmetrically as there are certain variations which we have endeavored to indicate by differences in the drawing of the two sides (Figs. 206 and 207). It will also assist the memory to refer here to the morphological basis of these cutaneous distributions. If the body were simply vermiform each segment of the cord would no doubt supply a simple circular band as in the dorsal region. Let it now be supposed that the worm-like body thrusts out a lateral bud which is to become the upper limb. Such a bud would pass out horizontally with the thumb upward and would carry out the various segments in succession from the fourth cervical to the second dorsal. Similarly the lower limb bud arising between the first lumbar and third sacral segments will carry out the intervening

segmental nerves in serial order but the arrangement becomes less obvious owing to the fact that the bud has undergone some rotation and no longer retains its primitive relationship of having the sole of the foot turned to the front and the great toe upward. It will, however, be obvious on examining the various areas that they have been drawn out from the trunk in this way. The branches from the fourth sacral and coccygeal nerves lie below the lower limb buds and fill in a small area on the perineum which is not visible in the diagrams. The highest trunk segment—the second cervical—is drawn up to the head and supplies the back of the scalp, the vermiform pattern being thus distorted by an upward expansion just as in the case of the limb buds it is distorted by lateral expansion.

An important regional group of symptoms is also met with in regard to the eyes. The centrum ciliospinale superius in the medulla oblongata is connected with the centrum ciliospinale inferius in the first dorsal segment by a series of fibers which run down the cervical portion of the cord. These fibers leave the cord principally in the first dorsal root and thence run as the rami communicantes to the inferior cervical ganglion and so return by the cervical sympathetic chain to the carotid and cavernous plexuses and to the eye. They include (1) motor fibers for the dilator iridis, (2) motor fibers for the muscular expansion (muscle of Müller) which holds the eyeball tensely forward in the orbit and (3) vasomotor nerves for the ophthalmic artery. Hence a crush in the cervical region will produce (1) paralysis of the dilator iridis with consequent contraction of the pupil, best seen in a dim light; (2) falling back of the eyeball with loss of tension and some approximation of the lids, causing a peculiar sleepy look; (3) variations in the caliber of the ophthalmic vessels which may be contracted or dilated, undergoing rapid changes and possibly leading to optic neuritis, a condition which results only from affections of the cervical region of the cord.

Irrespectively of the site of the lesion the results of a crush of the spinal cord will also depend upon the severity of the injury which has been inflicted. Such injury may consist in actual tearing of fibers and destruction of cells, or may be wholly or in part a hemorrhage with compression. Hence we may have a destroying lesion or a pressure lesion, and the two conditions will generally be combined. Of these the destroying lesion is probably irreparable, but if life be prolonged the pressure lesion may show a great amount of recovery so that function may be largely regained in all segments of the cord other than that

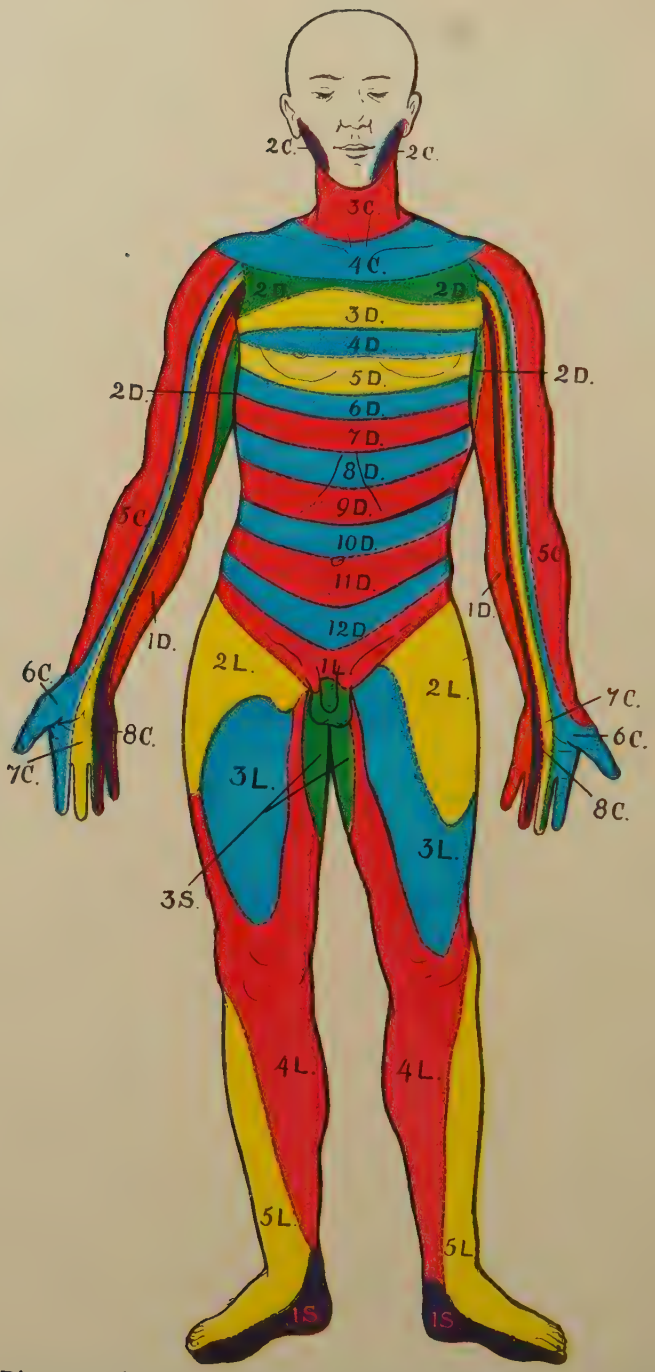

FIG. 206.—Diagrammatic representation of the sensory distribution of spinal segments (anterior view). (*Thorburn.*)

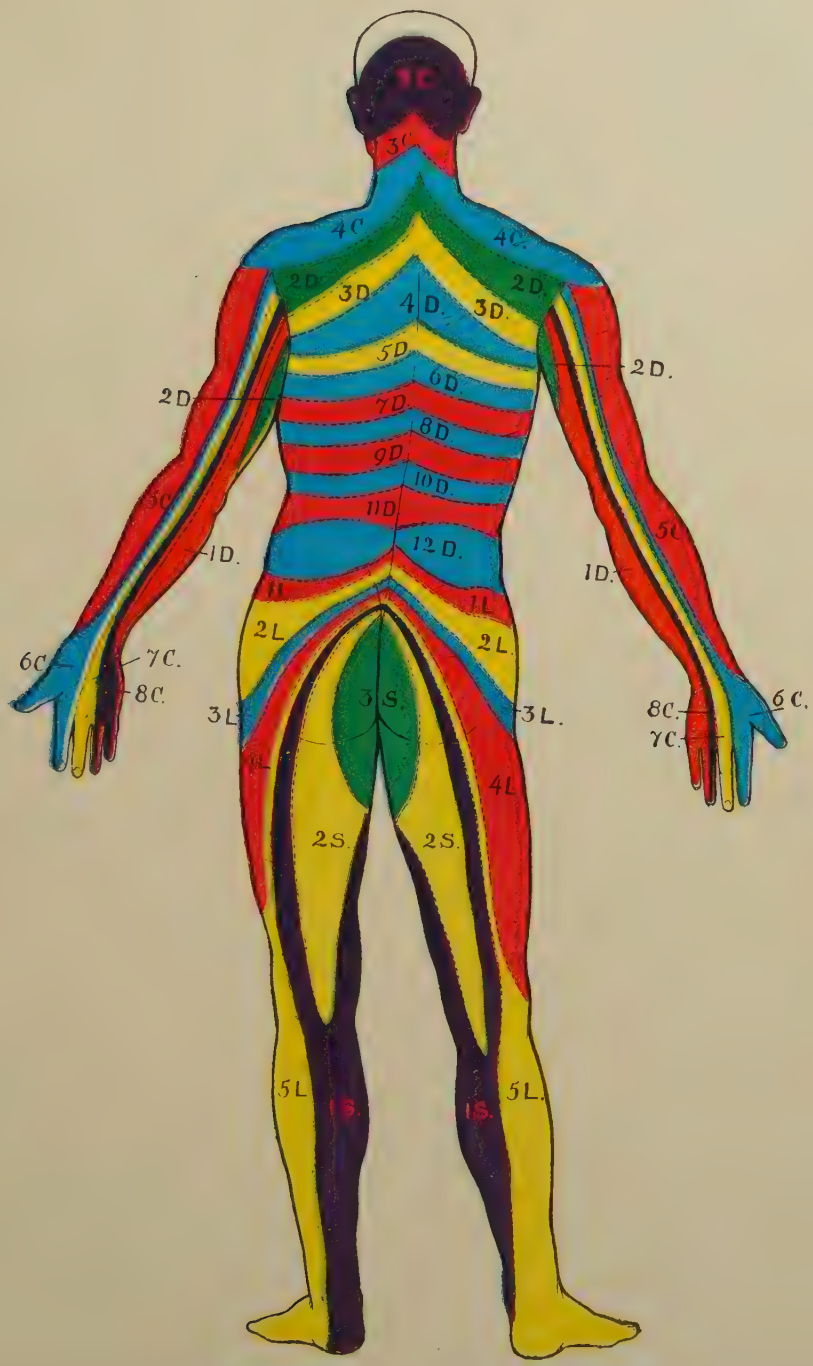

FIG. 207.—Diagrammatic representation of the sensory distribution of spinal segments (posterior view). (*Thorburn.*)

which has been actually crushed. Although, therefore, many cases die early from immediate shock, from respiratory paralysis or from some complication, others may long survive, and minor degrees of hematomyelia are by no means incompatible with an amount of recovery so great that the patient may experience little ultimate inconvenience, although in nearly all cases some of the muscles supplied by the injured segment will show an atrophic paralysis.

Crushes above the fourth cervical root are generally immediately fatal from respiratory paralysis or fatal in a few days from bronchopneumonia or from hyperpyrexia. When the injury is slightly lower, ascending myelitis may give rise to similar results, but respiration is less certainly paralyzed and life may be prolonged for many days or if the hematomyelia be small the patient may recover. As we descend into the dorsal region the danger of early death is much diminished and cases even of complete crush in the upper dorsal region may survive indefinitely. We are now, however, met by such complications as bedsores and cystitis. Bedsores may spread very rapidly, laying bare the sacrum and undermining the tissues of the back, and they are liable to be associated with metastatic infections and death from sepsis. Cystitis also leads to renal changes and death may occur from septic changes in the kidneys. In spite, however, of all these dangers to life, many injuries in the dorsal region leave their victim paralyzed but without the hope of early death.

When the skeletal injury is below the level of the first lumbar vertebra we no longer have to consider a crush of the spinal cord but of the cauda equina and the prospects of functional recovery are now much improved (*infra*, p. 614).

Diagnosis presents no difficulty except in the case of injuries of the lower dorsal and lumbar regions in which it may be difficult to distinguish crushes of the cord itself from those of the cauda equina, especially as these structures may be simultaneously involved. The distinction is, however, of importance as it considerably influences both prognosis and treatment. To some extent we can be guided by the local signs of deformity, remembering that the cord usually terminates at the lower border of the first lumbar vertebra while the various roots of the cauda equina remain in the vertebral canal until they reach their respective foramina of exit. We may also lay down the following general rules for diagnosis based upon the neurological symptoms, recognizing that no single one is entirely reliable: (1) Marked absence of bilateral symmetry indicates an affection of the

cauda equina. (2) The condition of the reflexes is very helpful. If the cauda is seriously crushed, the reflex arc is destroyed and the reflexes are absent. They are also absent if the cord be crushed through the segments in which they are generated, but if the cord be crushed above those segments they are often increased. Hence an exaggerated knee jerk, ankle clonus or an extensor reflex in the sole will definitely indicate that the cauda equina is intact and that the lesion is above the reflex centers, although the converse proposition would not be true. (3) Restriction of symptoms to a limited portion of the lumbo-sacral area or slow progress of symptoms to a gradually extending area indicate a caudal lesion, as in the lower part of the cord itself the segments are so crowded together that they seldom suffer separately. (4) Pain and hyperæsthesia here as elsewhere point to an affection of nerve roots rather than of medullary tissue. (5) In incomplete lesions of the cauda equina both paralysis and anæsthesia tend to affect the lower more than the higher roots.

Treatment of Injuries of the Spinal Cord.—From the moment at which the injury is received the greatest care must be taken in the handling of the patient and no attempt should be made to place him in a sitting or an erect posture. The diagnosis having been made, he should as quickly as possible be placed flat upon his back on a water bed or the best available substitute and in all future manipulations he should be moved only by turning him from side to side. If there be any obvious deformity an attempt may now be made to reduce it, with or without an anæsthetic, but in the great majority of cases it will be found that the spine has recoiled and that there is little or no displacement. A more precise diagnosis of the exact nature of the bony lesion will now be made, preferably with the aid of radiography, and the surgeon will consider the exact position and as far as possible the severity of the cord lesion. With these data he will decide whether or not to operate and he will also make arrangements for the general treatment which will be required in all cases of paraplegia whether operation is adopted or not.

As regards the value of laminectomy in recent crushes there is considerable difference of opinion but we may lay down certain general rules and may at least speak with some dogmatism of certain classes of injury.

Fractures of the spinous processes alone are rare, forming probably only about 2 or 3 per cent. of all cases, and in these the cord often escapes injury; but whenever there is evidence that a displaced spinous process is pressing upon the cord it should certainly be removed, it

being advisable to excise the whole of one or even two laminæ so as to ensure complete exposure of the injured region. Equally rare are fractures of the laminæ without injury to the bodies of the vertebræ but in these cases also laminectomy should certainly be performed.

In the far more common "fracture-dislocations" of the vertebræ it is usual for the upper of the two separated bones to be displaced forward so that the cord is crushed between its lamina and the posterior upper border of the vertebra below, the injury being possibly increased by traction upon the cord and theca owing to the extreme flexion to which the fracture is generally due. In many such cases the displaced bones remain displaced and there is continuous compression of the cord; in others, injury is at once followed by recoil of the spine and the lumen of the spinal canal is at once restored so that there is no continuous pressure on the cord and the sole remaining condition is one of hemorrhage and softening due to the temporary crush. Much more rarely the medullary injury is due to impaction of a detached fragment of bone, to a displaced intervertebral cartilage or to hemorrhage into the thecal or perithecal space.

Having regard to these various conditions it will be obvious that there will be differences in the possible benefit to be derived from laminectomy. Where the cord has been crushed and immediately released by recoil, as appears to be the case in some two-thirds of all these injuries, the only object of operation will be to give exit to effused blood or to suture the cord or theca. Where, on the other hand, continued displacement is present the narrowing of the spinal canal will be overcome by removing the arch of the upper vertebra or the posterior part of the body of the lower vertebra. Hence, then, the prospects of a satisfactory result from laminectomy are never good. If there be no persisting bony pressure, little is gained by removal of bone. If there be persisting bony pressure, such can be relieved but when it has been done the prospects of recovery will be at least no better than in cases of natural recoil—that is to say there will be little or no hope of functional recovery.

We may then lay down certain definite rules with regard to laminectomy:

1. In fractures of the arches or laminæ alone operation is certainly indicated.

2. In the majority of "fracture-dislocations" it is useless.

3. In a very few cases operation may reveal a large hemorrhage,

an impacted fragment of bone or other removable source of pressure or irritation.

4. Operation must, therefore, not be held out as offering any but the smallest hope of success but it is always justifiable as an exploratory measure and will be occasionally of value.

5. If undertaken, it should be complete and should include a search for and removal of all possible sources of pressure, including the backward projection of the body of the lower vertebra.

6. It should also be undertaken as soon as possible but should be delayed until the early period of acute shock has passed away.

Apart from laminectomy for the relief of pressure, suture of the cord has been practised in at least three cases in which partial recovery has ensued, but the writer does not consider that the passage of sutures through the substance of the cord is useful or advisable. On the other hand torn nerve roots present more tendency to recovery than does the medullary tissue and offer a better holding ground for sutures so that they should, when necessary, be approximated, while tears in the theca should certainly be closed.

Injuries of the cauda equina are less serious than those of the spinal cord as we are now concerned solely with nerve roots and in these cases we should certainly advise operation if the roots are known to be cut, torn, or subject to continued pressure. In many cases of fracture-dislocation below the level of the conus medullaris complete functional recovery has, however, followed even after weeks or months of paralysis and laminectomy is, therefore, required only in cases in which such recovery does not take place. Probably it is only necessary to perform immediate laminectomy in cases with marked displacement or other definite evidence of severe root injury. In minor cases we may wait for a few weeks and need operate only when assured that spontaneous recovery will not occur. Operation under these conditions is in marked contrast to operation for crushes of the spinal cord and has in many cases given excellent results.

Apart from laminectomy the treatment of injuries of the spinal cord consists in providing such a period of complete rest as will allow of the repair of the bony lesion and in dealing with the various complications which may arise. For the purely bony lesion about two months, confinement to bed in the recumbent position will usually suffice, and at the end of this time the patient—whether laminectomy has or has not been performed—may be propped up and shortly allowed to sit in a chair or walk about.

During the period of confinement to bed it will be necessary to guard most carefully against the formation of bed-sores, the condition of the bladder will require attention, and the general health must be carefully maintained. The diet should be light and the bowels will require careful regulation. The position of the limbs must be carefully watched as faulty attitudes are easily acquired and may become permanent. Talipes equinus is especially liable to result from pressure of the bed-clothes and a cage will generally be required over the feet. The body must be kept warm and dry, but hot bottles should never be used and reliance must be placed upon warm and easily removable wrappings. After the first week massage of the limbs should be adopted and all joints should be systematically moved while any motor power should be cultivated by practising active movements. Drugs are probably of little service, although hemostatics may be given with a view to diminishing hemorrhage in the early stages and morphia or bromide of potassium may be required. Belladonna is believed to diminish pain and motor spasm. Strychnia should never be given as its use increases the danger of spasm.

Retention of urine is usually present in serious injuries and will early require the use of the catheter. Having regard to the fact that the risk of infection of the bladder is very great, it has been advised that no catheter should be used, but such a line of action tends greatly to increase the risk of bed-sores and seriously injures the bladder itself in a case which may otherwise turn out fairly satisfactory, while, as a matter of actual observation, cystitis does ensue even when no catheter is used, organisms probably entering the bladder by the dilated urethra with its continual stream of overflowing urine. Hence, in all cases of retention the catheter should be regularly employed.

The most careful precautions are required in its use. Previous to its introduction the prepuce, glans, and meatus should be carefully washed with 1 in 2000 solution of corrosive sublimate, and it is also wise at all times to keep the end of the penis wrapped in lint wet with a 1 in 5000 solution. The catheter may be of silver or rubber, the former being most easily rendered quite aseptic while the latter is less likely to inflict injury on the urethra; on the whole, we prefer silver, and in experienced hands there should be no risk of injury. After use the instrument should be washed and syringed out with cold water and then boiled; it is then kept in a solution of carbolic acid (1 in 20) and again boiled before using. An excellent method of cleaning the bore of the catheter is to blow down it steam from a Ward-Cousins'

boiler, or the instrument may be kept in formalin vapor in one or other of the boxes or jars sold for that purpose. The lubricant should be sterile, and for this purpose we prefer liquid paraffin, which can be kept in a deep bottle and sterilized by heating in a water bath before use, or we may use collapsible tubes of any sterilized lubricant. Lastly, care should be taken not to allow air to enter the bladder as the instrument is withdrawn.

In some cases retention of urine is replaced by a *reflex incontinence*, the bladder emptying its contents at frequent intervals. Here the catheter is not required, but the glans penis should be protected as in retention and the patient should have a glass urine bottle frequently sterilized by boiling.

When *cystitis* has occurred, it becomes necessary to wash out the bladder frequently, say three times daily, with some antiseptic solution, using the same precautions as in catheterization. Such washing should be conducted by means of a funnel and tube and not by a syringe, which is difficult both to clean and to control. The most various antiseptics have been used for this purpose, but probably an isotonic solution of boracic acid (1 in 20) or even isotonic saline solution alone is as useful as anything, and the bladder should be left empty by syphoning out the last drops of urine. When the urine is highly alkaline and full of sticky mucus we may add 5 grains of sulphate of quinine and 10 drops of dilute sulphuric acid to each ounce of the lotion. Hemorrhage may be checked by giving hamamelis by the mouth or by introducing adrenalin into the bladder, but calcium chloride must not be given as it increases the tendency to form firm clots which are difficult to evacuate.

Equally important with the management of the bladder is the *prevention of bed-sores*, by protecting the points of pressure, such as the back-heels and the great trochanters, the dorsum of the toes which may be pressed upon by bed-clothes, and the knees, which may either receive the weight of the bed-clothes or be pressed together, especially in cases of spasmodic contraction. The patient should be placed upon a water bed from the first, and the most scrupulous care is necessary to avoid soiling by fæces or urine, the escape of crumbs of food, or the formation of folds in draw sheets and bed-clothes. A cage should protect the feet not only to prevent bed-sores, but also to prevent the weight of the clothes increasing the formation of a talipes equinus. Pads of the shape of a large corn plaster or a small life buoy must be used to protect all points of pressure, and any marked kyphosis due to the injury must

especially be watched. If there be much perspiration the clothing should be frequently changed.

All points of pressure should also be carefully inspected twice daily and thoroughly washed, gently dried with cotton wool, then rubbed lightly with alcohol and finally dusted with powdered boracic acid. Should redness supervene, it is well to use some balsamic preparation and the part may be painted with collodion flexile or protected by a thin sheet of gauze, painted with compound tincture of benzoin or dressed with lint spread with balsam of Peru. Lastly, should sloughs form they must be dressed with some antiseptic ointment, such as the officinal unguentum boracis, and after their separation healing is promoted by zinc ointment.

Tuberculosis.—Tuberculous disease *of the spinal cord* is met with in miliary tuberculosis in which it has no surgical interest and also as a result of the extension of tuberculous spinal meningitis to the cord, but solitary tuberculous masses are rarely found. When such occur, they form distinct nodules resembling tumors and producing symptoms identical with those of intramedullary tumors, but are usually of more rapid development. In one such case the writer exposed a tuberculous mass in the center of the brachial enlargement, opened and drained the dura mater but made no attempt to excise the growth; the result was a very rapid and perfect recovery from an almost complete paraplegia, but symptoms recurred two years later. Excision of the intramedullary nodule would not have been practicable without extensive injury to the cord.

Tuberculous *spinal meningitis* is usually associated with tubercle of the cerebral meninges and is not susceptible to surgical treatment.

Tuberculosis *of the vertebral column* is a common source of spinal paraplegia, although the frequency with which this complication ensues is difficult to estimate, the figures of various clinics showing a percentage of paraplegia to caries varying as widely as from 7 to 20. In such cases the paraplegia is rarely due to mere kyphosis and the spinal canal at the seat of the angular curvature is often widened rather than narrowed, while paraplegia is more common in those cases in which angular curvature is not very marked. In some cases, however, tuberculous disease is followed by fracture of the weakened spine, when the cord may be crushed by acute bending as in other injuries. In other and equally rare cases pressure is produced by hemorrhage, by the projection of sequestra into the vertebral canal or by the sudden rupture into it of large abscesses. Occasionally, also, a tuberculous perimeningitis

spreads directly to the cord which is thus itself infected and presents a transverse tuberculous myelitis.

Setting aside all these rare causes of paraplegia in Pott's disease, we find that in the very great majority the complication arises from the gradual filling of the spinal canal by tuberculous granulation tissue which does not penetrate the theca and which may remain as soft granulations or may caseate or liquefy, or which may lead to a dense fibrous peripachymeningitis with formation of a thick leathery cicatricial tissue around the dura mater. In all such conditions the usual result is, therefore, the formation of a perithecal mass of varying consistency which presses upon the cord and produces in the latter secondary changes similar to those of other compressing lesions.

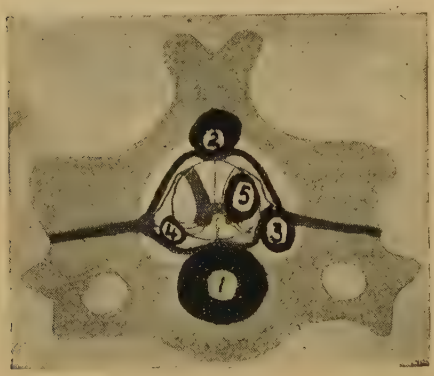

FIG. 208.

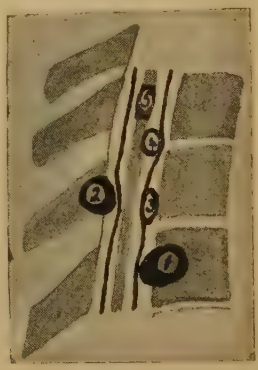

FIG. 209.

FIG. 208.—Tuberculous lesions. 1, Arising in body of vertebra; 2, arising in spinous process; 3, extra-thecal; 4, intra-thecal; 5, in the cord. (*Williamson.*)

FIG. 209.—Tuberculous lesions. 1, In body of vertebra; 2, in spinous process; 3, extra-thecal; 4, intra-thecal; 5, in the cord. (*Williamson.*)

The symptoms produced resemble in many respects those of tumors and take the form of suddenly developed or more often of a gradually increasing paraplegia with anæsthesia, exaggeration of the deep reflexes and paralysis of the bladder and rectum. Pain at the seat of pressure and in the distribution of the nerve roots arising from that area is common, but is not so marked or so definite in its distribution as with tumors nor does it long precede the development of paraplegia. The evolution of symptoms is as a rule more rapid in cases of tuberculosis, but anæsthesia is seldom so complete as in tumor cases.

The surgical treatment of paraplegia due to tuberculosis of the vertebræ will be governed in the first instance by a consideration of the

seat of origin of the bone disease (Figs. 208, 209). In rare cases this may be confined to the spinous processes, laminæ or articulations, or it may have extended from the costovertebral joints. In such, a radical operation is practicable and we may remove the whole focus of disease, at the same time relieving the cord from pressure. Operation should, therefore, unhesitatingly be recommended and excellent results may be obtained, but unfortunately such cases will rarely be met with.

In paraplegia due to tuberculosis of the vertebral bodies laminectomy allows of the removal of tuberculous tissue pressing upon the cord and the latter may undergo functional recovery as it does after the removal of tumors, but total eradication of the disease is unfortunately often impossible. It has also to be borne in mind that a very large number of cases of paraplegia in Pott's disease will undergo spontaneous recovery if the patient be kept rigidly at rest in bed or in some form of body splint. Hence the surgeon has to consider three essential questions before advising laminectomy, viz.: (1) Many cases will recover with rest alone. (2) In some, the cord will be so far degenerated as to be incapable of recovery even after operation has been performed. (3) The primary focus of disease cannot as a rule be excised and recurrence of pressure and of paraplegia is very liable. For these reasons we now seldom resort to laminectomy in tuberculous paraplegia, but the following may be accepted as general rules for guidance:

1. Operation should not be performed when the general condition is very bad, when active tubercle is present in other regions of the body, or when local activity is indicated by rises of temperature or by a rapidly increasing kyphosis.

2. Operation should not be performed if there is radiographic or other evidence that the bodies are so far destroyed that excision of the laminæ would remove the main support of the spine.

3. The majority of cases should first be treated by a period of *complete* rest and fixation, and if improvement ensues this should be patiently continued even up to two years or more.

4. If in spite of complete rest symptoms be steadily increasing, or if after say six months they show no signs of improvement and especially if there be marked spastic troubles, then laminectomy becomes advisable.

5. In cases of very sudden onset seen at an early date it is wise to operate at once, as in such cases the immediate relief of an abscess, hemorrhage or displacement may avert serious pressure changes.

Guided by these rather strict rules of limitation we have found a

comparatively small number of cases which appear to us to call for operation, and the results have naturally been far less favorable than they would appear to be if many cases were operated upon at an early stage without awaiting spontaneous recovery. About one-third of all our cases have been unrelieved, one-third are relieved but paraplegia recurs, and in the remaining third there is either great relief or complete recovery.

Non-tuberculous Infections.—Infective diseases of the spinal cord other than tuberculosis are so fully described in textbooks of medicine that we can here deal with them very briefly, especially as they rarely call for surgical intervention except when they give rise to granulomata which resemble tumors in their symptoms and treatment. Thus syphilis and actinomycosis will generally in the first instance be treated medicinally, while the more definite pressure lesions will be dealt with by excision on lines similar to those adopted for the treatment of tumors.

In this connection we may, however, refer to cases of obscure pathology described by Horsley as "chronic spinal meningitis" and including probably syphilitic, influenzal, gonococcal and other forms of meningitis. Such cases resemble and have very generally been mistaken for tumors of the cord, but differ mainly in that pain is less definitely localized, there are often widely spread hyperæsthetic areas, anæsthesia is incomplete and without dissociation, paralysis takes the form of a rather widely spread weakness without definitely segmental type, and vasomotor symptoms are absent. The patients are usually adults and the upper level of anæsthesia tends to be mid-dorsal, while kyphosis is not rare. In such cases, free laminectomy with opening of the dura mater by a long incision has been followed by marked improvement, and operation has revealed thickening of the arachnoid with excess of cerebro-spinal fluid and adhesions of membranes or "matting of nerve roots." We have had several rapid recoveries after laminectomy in cases which fall into this ill-defined group, and it is not improbable that at least some of the system diseases of the cord or some forms of transverse myelitis originate in a meningitis due to infection extending upward along nerve roots and that early incision and drainage of the theca would, therefore, be of value in such cases. In a few cases of locomotor ataxia we have also certainly seen great improvement after mid-dorsal laminectomy and drainage.

Tumors.—*Tumors* involving the spinal cord may arise from the bodies or arches of the vertebræ, from the perithecal tissue, from the

meningeal tissues inside the theca or very rarely from the spinal cord itself, the various situations being indicated in the following diagrams from Williamson. All except the last cause symptoms of compression, while intramedullary tumors produce symptoms similar to those of transverse myelitis.

Tumors *of the vertebræ* are generally malignant and include as primary growths sarcoma and myeloma and as secondary growths carcinoma, sarcoma and lymphosarcoma; benign tumors such as exostoses, angiomata, chondromata and myxomata are all very rare. In such cases of vertebral growth the spinal column may or may not be deformed, but in malignant disease it generally presents some rounded curvature and some rigidity. Pain is usually an early and severe symptom, affecting the back locally and spreading along the distribution of such nerve roots as are pressed upon. As the lumbar vertebræ are the usual seat of attack, pain may take the form of what is regarded as a double sciatica, while in the dorsal region it assumes the girdle type. Paralysis and anæsthesia of and below the affected segment now rapidly supervene and the case assumes the usual type of a transverse lesion of the cord. The diagnosis will rest largely upon the evidence of primary or secondary tumors in other regions of the body, the presence of local hyperæsthesia or rigidity, the great severity of the pain and the results of a radiographic examination. Many cases closely resemble the paraplegia of caries, but in tumors both pain and anæsthesia are as a rule more marked and the age and general condition of the patient may assist the diagnosis. It will be obvious that the majority of these cases are not amenable to surgical treatment, but life may be prolonged by laminectomy with excision of as much of the growth as can be reached, while in a few cases, as in one of the writer's, non-malignant vertebral tumors have been found and successfully excised.

Tumors *of the extradural space* are less common than those within the theca, but may arise from the dura mater itself, from the lax cellular tissue which surrounds it or from tissue external to the spine, the growth having penetrated the intervertebral foramina. Such growths comprise nearly all varieties of tumor and of cyst and all produce a compression myelitis which is practically indistinguishable from that of the intrathecal tumors. Their position can hardly be recognized before exploration and, apart from collateral indications such as secondary growths, we can hardly judge whether they are or are not malignant. As, apart from operation, they are inevitably fatal, all cases should be

explored, and there are about 40 recorded examples of their successful removal.

Intrathecal tumors arise from the dura mater, arachnoid, pia mater or spinal nerve roots and present a wide diversity of structure, including sarcoma, fibroma, psammoma, myxoma, lipoma, endothelioma, angioma, lymphangioma, neuroma and cysticercus. The majority do not, however, appear to be malignant and even the so-called sarcomata of this region show little tendency to recurrence after removal. In the great majority of cases the dorsal region is attacked, and the symptoms are often very characteristic. The spine itself is unaffected or may be slightly kyphotic. Pain is generally the first symptom and may be well defined for a long time before other troubles arise, so that we may have a history of "neuralgia" preceding paralysis or anæsthesia and persisting for months or even for a year or two. Such pain may be unilateral, but tends eventually to involve both sides of the body and takes the form of a girdle pain or less often of a "double neuralgia" of the upper or lower limbs. At a later date the usual symptoms of compression myelitis will ensue, and will soon assume the ordinary type of a transverse lesion, although they may at an early stage present the Brown-Séquard syndrome of homolateral paralysis with contralateral anæsthesia. Should the lesion involve the cauda equina, which is rare, paralysis and anæsthesia will, however, coexist on the side exposed to pressure. All cases should be explored but it is to be remembered that in many the tumors are not single and also that they present a great tendency to extend vertically for a condsiderable distance so that a free laminectomy is often necessary. The results of removal are generally very satisfactory. The cord shows a marked power of repair after even prolonged compression and the tendency to recurrence is slight, so that intrathecal tumors yield more favorable results from operation than does any other variety of disease of the spinal cord, and in the writer's experience about one-half of all cases have been followed by functional recovery, at least sufficient for the patient to carry on the duties of life. In some cases, no doubt, it will be found impossible fully to remove the growth, in some the cord will have been compressed beyond repair and in some we shall meet with recurrence, but in all about 50 successful results have now been recorded.

Intramedullary tumors are fortunately very rare. They are not as a rule preceded or accompanied by marked pain but produce symptoms like those of transverse myelitis, except that the course is less rapid. Trophic changes are as a rule very marked and analgesia and thermo-

anæsthesia usually precede tactile anæsthesia. The diagnosis can, however, hardly be established without exploration and, unfortunately, if an intramedullary growth be discovered, it cannot be removed without injuring the cord to such an extent as to cause some permanent paraplegia, although in a few cases life has been saved and a moderate amount of functional recovery has been attained by the enucleation of these growths. So far as the writer is aware no surgeon has yet had the temerity deliberately to perform a transverse section and suture of the medulla.

Operations.—Apart from paracentesis and operations for the introduction of anæsthetics into the spinal theca, the only operation upon the spinal cord which calls for consideration is laminectomy or removal of the vertebral arches followed by such minor variations in detail may be required by the nature of the case. Laminectomy has, however, been adopted under very various conditions and wide modifications are required under special circumstances, but the general outlines of the operation are so similar in all cases that it may here be treated as a single operation. Before describing its technique it is only necessary very briefly to recapitulate the various indications for its performance most of which have been fully dealt with in the immediately preceding pages although a few do not fall within the scope of this article. Such indications are:

1. The early or primary treatment of injuries of the cord especially when due to punctured wounds, fractures of the laminæ and hemorrhage (pp. 600, 612).

2. The later or secondary treatment of paraplegia following injury and due to callus or to cicatrices.

3. Injuries of the cauda equina (p. 614).

4. Tuberculous or other rare forms of spinal caries causing paraplegia (p. 618).

5. Tumors and cysts involving the cord (p. 621).

6. Spina bifida occulta and the cicatrices of healed spina bifida (p. 593).

7. Chronic spinal meningitis (p. 620).

8. Neuralgia of spinal nerves.

9. Spastic conditions following certain cerebral lesions such as "Little's disease."

As regards the *preparation* of the patient a few details call for attention. The skin requires careful preliminary disinfection as it is coarse and thick with numerous deep follicles, while it is often much

soiled by the presence of bed-sores. When possible, such bed-sores should always be induced to heal before operation but if this cannot be done they should be most carefully disinfected and a separate dressing should be placed upon them before the operation and should not be disturbed during its course. The sore being generally well below the

FIG. 210.—Bed-trolley ready to be pushed under the bed. (*Thorburn, Burghard's Operative Surgery.*)

proposed vertebral opening, such a dressing can usually be sutured in position. In cases of exploratory laminectomy, and of operations upon all forms of disease which may be of infective origin we have of

FIG. 211.—Bed-trolley in position for carrying the bed. (*Thorburn, Burghard's Operative Surgery.*)

late administered large doses (60 grains) of urotropin before the operation.

In recent injuries great care is required in moving the patient and in all cases we prefer to bring the bed to the operating table and commence anæsthesia in the bed, subsequently lifting the patient on to the table and adjusting him as described below. After the operation he is

again transferred directly to the bed and a good deal of unnecessary movement is thus saved. For the purpose of thus bringing the bed

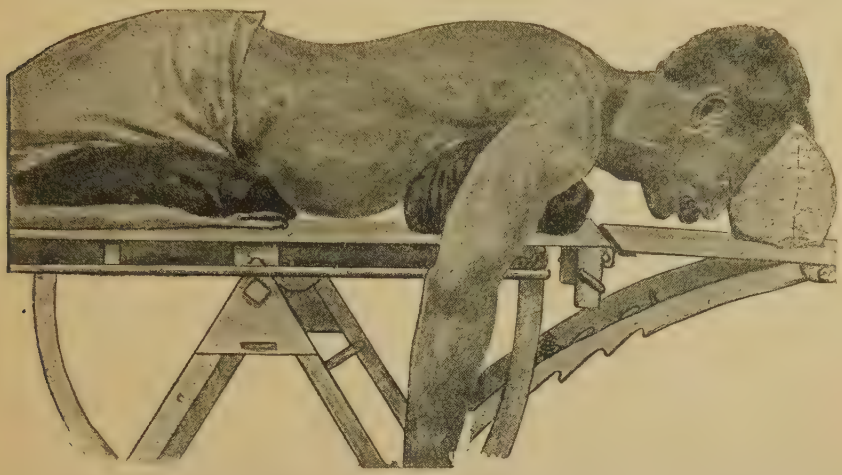

FIG. 212.—Attitude for laminectomy in the dorsal and lumbar regions. The arms would rest upon the table but are here drawn hanging down to show the space allowed for respiration. (*Thorburn, Burghard's Operative Surgery.*)

into the operation theatre a bed-trolley (Figs. 210, 211) will be found highly convenient.

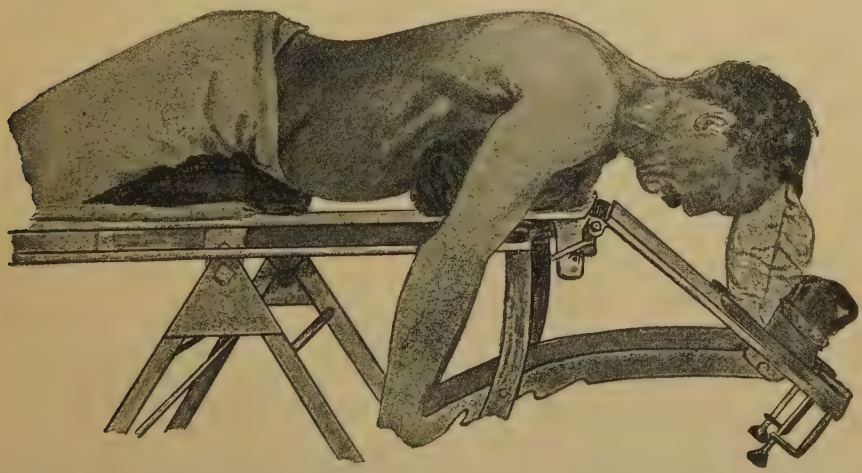

FIG. 213.—Attitude for laminectomy in the cervical region. The neck is more fully flexed than in the previous figure. The arms should rest upon the table. (*Thorburn, Burghard's Operative Surgery.*)

Many surgeons operate with the patient lying on the side, but, except in very limited cervical hemilaminectomy, we greatly prefer the

prone position. In order to carry this out satisfactorily it is, however, necessary to arrange pillows so as to support the chest and pelvis and to leave the abdomen quite free for respiration. The annexed drawings taken from photographs of the actual positions will best illustrate how this can be done without embarrassing respiration or interfering with the anæsthetist (Figs. 212, 213). One sand pillow supports the upper sternum, avoiding pressure upon the trachea, and another is placed under the pelvis, while the forehead is supported by a third small cushion which must in cervical operations allow full flexion of the neck. In all cases the mouth is kept well away from the table.

For *anæsthesia* we have always used chloroform or chloroform and oxygen; it is more easily handled than ether and is less likely to irritate the lungs whose condition must always give rise to anxiety in high lesions of the cord. Local anæsthesia is, however, occasionally employed, the most satisfactory method being that of Braun, who injects freely a solution of novocain and adrenalin, thus simultaneously producing anæsthesia and rendering the operation almost bloodless.

Certain special *instruments* are required. The knife should have a large and strong blade, while for the deeper incisions a blunt-ended resection knife is useful. A fine tenotome and iris scissors are employed for opening the dura mater. The retractors should be capable of thoroughly exposing a deep wound and in some cases two pairs are required. To the above must be added ordinary dissecting instruments and fine-toothed forceps for picking up the dura mater. The bone instruments include one or two strong raspatories, a chisel for scraping the bone, Horsley's or Doyen's saw, several pairs of strong bone forceps set at different angles, rongeur forceps and sequestrum forceps. Some surgeons use a trephine and for osteoplastic laminectomy a Gigli saw is required, but we do not employ these in the ordinary operation. For clearing out tuberculous foci the surgeon must be provided with scoops or curettes and for enucleating tumors fine raspatories are required, or a Horsley's aneurism needle will be found extremely useful. A large douche can containing a 1 in 10,000 solution of corrosive sublimate in isotonic salt solution at a temperature of 115°F. is of great value for checking hemorrhage or for washing out tuberculous foci.

The more convenient *incision* is vertically over the spinous processes, except in cases of angular curvature in which it is better to raise a curved flap from one side so as to place the superficial wound well away from the projecting spines. A free cut is thus made down to the spinous processes when the muscles on either side can be rapidly sepa-

rated by cutting on to the laminæ. No attempt need be made at this stage to deal with bleeding but the muscles are rapidly retracted and firm pressure is then made on each side for a minute or two. If this be done it will be found necessary to pick up with forceps very few, if any, blood-vessels. The spinous processes will thus be freed and exposed as a central ridge and they can be cut away from above downward by strong forceps. The interspinous ligaments are taken with them, and the bony and ligamentous chain thus cut away from the laminæ may be at once removed or may be left attached at its lower end to be turned back and sutured into place at the close of the operation.

The laminæ are now fully exposed and any residual bleeding arrested, after which the arches to be removed are thoroughly cleared with the edge of the chisel. As soon as the bony surface is cleanly exposed it is cut through by the Horsley's or Doyen's saw, the cut commencing outside the center of the laminæ and running obliquely inward toward the verebral canal, which need not, however, be entered. The further and final section is now best made with bone forceps, or in the cervical region, in which it is difficult to apply the saw, bone forceps alone will suffice. In using the forceps care should be taken not to push the points far into the vertebral canal and the instrument when closed is used to lever up the cut laminæ. Finally, the strong ligamenta subflava must be cut with scissors at the upper and lower ends of the bony openings after which the lamina can be removed. After the first opening has been made it is most easily extended by the use of rongeur forceps. In all these manipulations the greatest care is, of course, necessary not to wound the theca or cord; but except in traumatic cases these are very rarely so near the laminæ as the inexperienced operator might anticipate, and there is normally a space of at least ¼ in. between the deep surfaces of the bones and the back of the theca.

The vertebral canal having been opened, the subsequent operative steps will depend upon the condition to be dealt with. In recent injuries blood clot will be removed and the theca fully exposed, when tears of the dura mater or cut nerve roots should be sutured. A few surgeons advise suture of the spinal cord and all agree that every source of pressure should be removed, and that if the body of the lower vertebra be projecting, it should be chiselled away, which can be done by holding the theca aside with an aneurism needle. In old injuries, and in tuberculous peripachymeningitis, cicatricial tissue should be carefully and completely excised and extrathecal tumors are dissected away, the dura mater being unopened. Tuberculous abscesses should be opened and

their contents scraped away, and it is most important to note that in tuberculous cases the theca should never be opened.

Assuming that the theca has not been torn and that the condition to be dealt with lies within it, the next step of the operation will be the careful opening of the dura mater in the middle line, which is commenced by a slight stab with the tenotome, the small puncture being extended by the scissors so as to allow free exposure of the spinal cord. The two lips of the cut theca are then most conveniently held open by passing sutures through them and retracting these sutures with Spencer Wells' forceps of which the weight alone is sufficient. At this stage the unopened arachnoid often bulges out like a cyst and is laid open by a touch of the tenotome. It is now quite practicable to enucleate an intrathecal tumor or to divide nerve roots, whichever be the objective of the operation, and it is also possible to excise tumors from within the cord itself or to tap the cavity of a syringomelia, although such proceedings are little likely to yield satisfactory results.

The *closure of the wound* should be carefully carried out as upon it depends the future strength of the back. In cases of chronic meningitis and in exploratory operations which have revealed myelitis of probable infective origin, we leave the dural incision open for purposes of drainage, but in all other cases it is closed by interrupted sutures of fine catgut placed about ½ in. apart. The muscles of the back are then approximated in at least two layers by strong catgut sutures, and if the ridge of spinous processes has been preserved it is secured in its position by the same suture. Finally, the skin is closed without drainage.

In addition to a typical laminectomy, such as has been described, there are a few important modifications of technique applicable to special cases. The term *hemilaminectomy* is applied to operations in which, owing to the nature of the case, a sufficient exposure can be obtained by the removal of the laminæ on one side only. Thus in the cervical region in which growths can be localized with much accuracy and where the laminæ are easily divided and superficially placed, it is at times possible to do all that is required without crossing the middle line and similarly posterior root section may be carried out by a unilateral operation, but such partial resections do not differ in technique from the more usual and complete method.

Ingenious operations have also been devised for the wiring together of spinous processes to give additional support after fractures and the method of "*osteoplastic resection*" of the spine by which all the laminæ are preserved and reimplanted has also been advocated with a view to

obviating any weakening of the spine, but such modifications appear to the writer greatly to complicate a sufficiently difficult surgical technique without corresponding advantages. The method above described is one which I have followed in very many cases and I have never had difficulty from weakening of the back. That osteoplastic laminectomy is an attractive operation and that it thoroughly restores the anatomical relation of parts there can be no doubt, but it has the grave disadvantage of not allowing any extension of the incision.

The *after-treatment* of laminectomy entails attention to the various details referred to in connection with the non-operative treatment of injuries of the spinal cord, but seldom presents any serious difficulties and the wounds heal very readily and firmly. A free escape of cerebro-spinal fluid may occasionally occur and may necessitate a change of dressing, but we have not found any serious inconvenience from this condition. Shock is often severe but is usually quickly recovered from and we have only twice seen a fatal result, one being in the case of a child with spinal caries in whom after operation the softened bodies of the vertebræ completely collapsed. In cases in which much shock is anticipated it is, however, quite practicable to resort to a *two-stage operation*, the first stage including the removal of the laminæ and the second concerning itself with the opening of the dura mater and such other proceedings as may be called for. We have not hitherto found it necessary to adopt this course, but with some surgeons it is almost a routine practice and in cases where there are on acute symptoms it has much to commend it. Shock can also be greatly lessened by infiltration with novocain by Braun's method. Finally, it is advisable after all extensive operations or those in which there is disease or injury of the vertebral bodies to support the spine by applying a carapace of poroplastic felt before the patient is replaced in bed, but where the bodies are not diseased this is rarely if ever necessary, and the back will be found to be quite strong enough for the patient to sit or stand within a month of operation.

As regards the general *results of operation*, it is not easy to form any accurate estimate of its dangers as many cases have been in so serious a condition that death has resulted from the unchecked course of the disease. In a personal experience of over 50 cases there have been three deaths, which could be regarded as due to or hastened by operation; two were due to shock, both occurring in cases of extensive tuberculous disease of the vertebral bodies, and one apparently resulted from re-extension of myelitis in a case of old injury to the cervical region, while

in such conditions as tumors, explorations and the like we have had no unfavorable results from operation. The results as regards the cure of the disease and functional recovery on the part of the spinal cord will naturally depend upon the conditions for which the operation has been undertaken, and can only be considered in connection with the general aspects of the case to which reference has been made in the preceding pages.

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